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ROENTGEN KYMOGRAPHY AS A DIAGNOSTIC AID[1]

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THE use of kinetic phenomena as diagnostic aids in medicine has long been customary. Movement is certainly one of the basic factors of life in general. Attention has always been paid in roentgenology to movements within the body. In the last few years one could observe that the interest has shifted to the exact study of morphology. This was due to the enormous development of photographic technic which made it possible to produce structural films of undreamed-of clarity and delineation in a short space of time. In daily practice only the fluoroscope was at hand for the study of movement. Its disadvantages are well known. Aside from bad visibility, the subjective nature of the observation which allows the greatest freedom of deductions is not advantageous.

It was my intention to give to the studies of movement the advantages of photographic fixity. I did this in the hope that it would lead to an increase in our knowledge, just as photography accelerated our studies of morphology. For this purpose I have developed the method of kymography, which has been applied in medicine as a procedure for the recording of moving parts, as in pulse records, and kinetics in general.

The recording of movement by kymography depends in principle upon the equivalent change of the recording point during the filming. This is due to the fact that the single time films do not overlap. As an expression of the movements a curve is formed which shows no gaps in time. The earlier attempts at roentgen kymography limited themselves to a recording of the movement of individual points on an organ. Such a procedure would be useful if the movements of all points on an organ were equivalent as they are in solid inanimate bodies. But this is not the case. The changes in form during movement are always manifold since we are dealing with elastic masses. Therefore, the recording of movement must be extended to a whole plane. Only in this way is it possible to follow the changes in movement as well as in form of an organ.

These kymograms have the particular advantage that they fix all the movements in a curve, subject to objective interpretation, and that furthermore, there exists the possibility of visualization of the movements again as a sensory impression.

For diagnosis we use both types of interpretation. For the small and rapid movements of the heart the curve serves better; for the complicated gastric movements the general picture of the process is usually more important.

Movements in the interior of the body have varying causes. We distinguish between primary and secondary movements. The division of those two forms is unthink-

[1] Presented before the Fifth International Congress of Radiology, in Chicago, Sept. 13–17, 1937.

Fig. 1-*a* (*upper left*). In the case of alterations of the myocardium (infarct), the curves show changes at a distinctly limited area.

Fig. 1-*b* (*upper right*). Section of the kymogram from the left ventricle.

Fig. 2-*a* (*lower left*). When the muscles refuse completely to act, the wall is turned out during the systole. This may be recognized by the displacement of the curves.

Fig. 2-*b* (*lower right*). Section of the kymogram from the left ventricle. Arrows show contrary movements in the ventricular region.

able by purely technical means. This is possible only through a thoughtful interpretation of the fixed images. This applies to normal and pathologic movements.

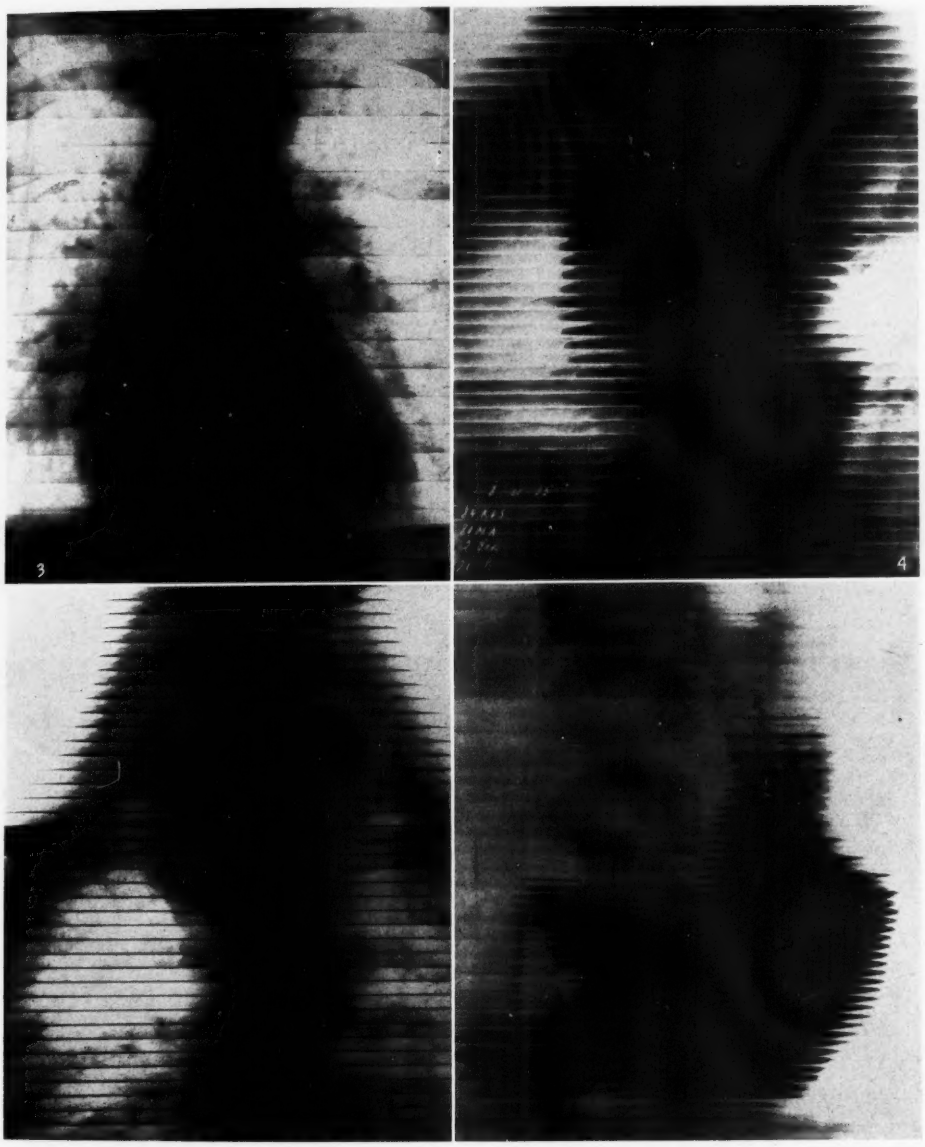

Fig. 3 (*upper left*). In the case of pericardial alterations (concretio-pericardii), we note a stoppage of marginal movements.
Fig. 4 (*upper right*). Kymogram of the swallowing movement in a case of freely movable goiter.
Fig. 5 (*lower left*). In case of mediastinal adhesions, there is no movement.
Fig. 6 (*lower right*). Kymogram of a normal stomach (exposure 60 sec., 6 ma., 80 kv.).

This division is not a technical but a purely medical problem. As in morphology in which there are many variants of the normal development of organs, so is the number of varieties of movements even larger. The recognition of pathologic movements demands great experience and much thought. The development of kymography has been rapid, but not at all completed as yet, since further close study also

Fig. 7. Film shows the movement of gastric mucosal relief, taken with patient lying down. Very little opaque meal used. The folds are becoming broad and narrow according to the movement of the exterior wall.
Fig. 8. Movement of the folds in a case of gastritis. Folds show little and disordered movements.

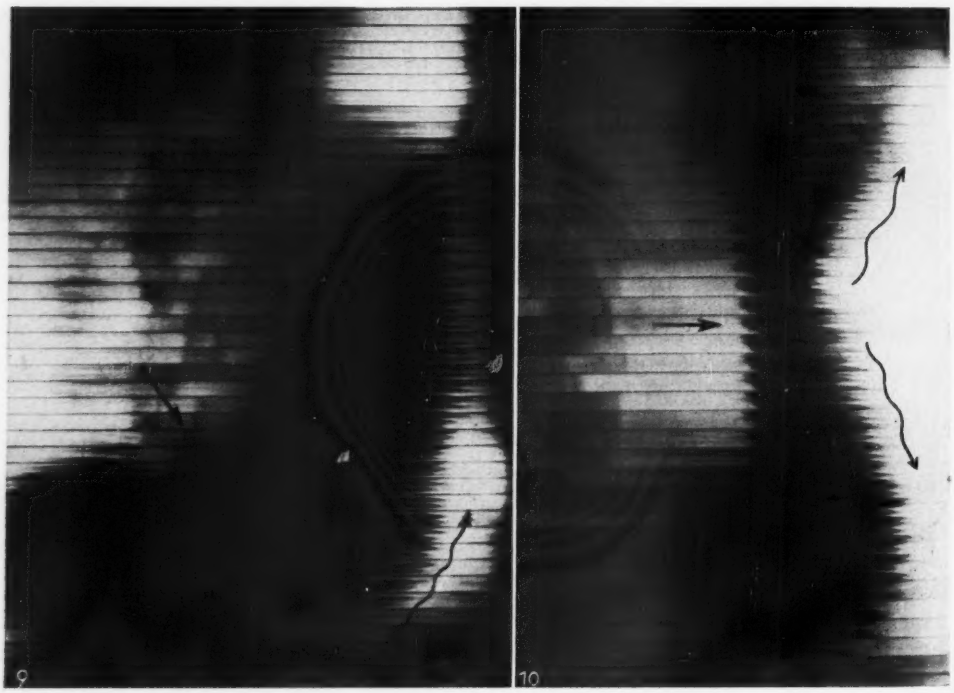

Fig. 9. Ulcer of the stomach showing a niche. The niche shows only a passive movement. We also note other motor disturbances (partial retroperistalsis).
Fig. 10. Ulcer of the posterior wall showing partial retroperistalsis in the segment of the ulcer. Arrow shows the ulcer.

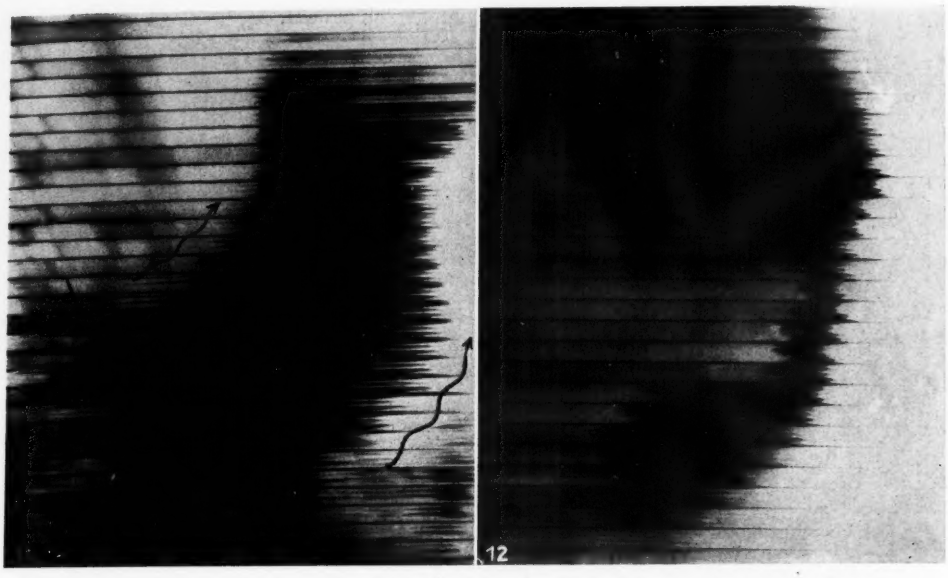

Fig. 11. In a case of pyloric ulcer we diagnose a perfect retroperistalsis but no delay in emptying.
Fig. 12. In case of cancer the rigidity shows the extension of malignant infiltration.

Fig. 13. Dissection showing the ulcer (arrow).

increases the knowledge of normal variations. Kymography has for its aim the making of more objective fluoroscopic observations, thus to bring into view processes of movements not recognizable by other means.

I shall attempt to show you by means of films how the kymogram has solved these problems.

The "planar kymograms" are obtained by the interposition of a moving drum which is moved in equal distances during the exposure. One obtains numerous curves which cover the surface of the film.

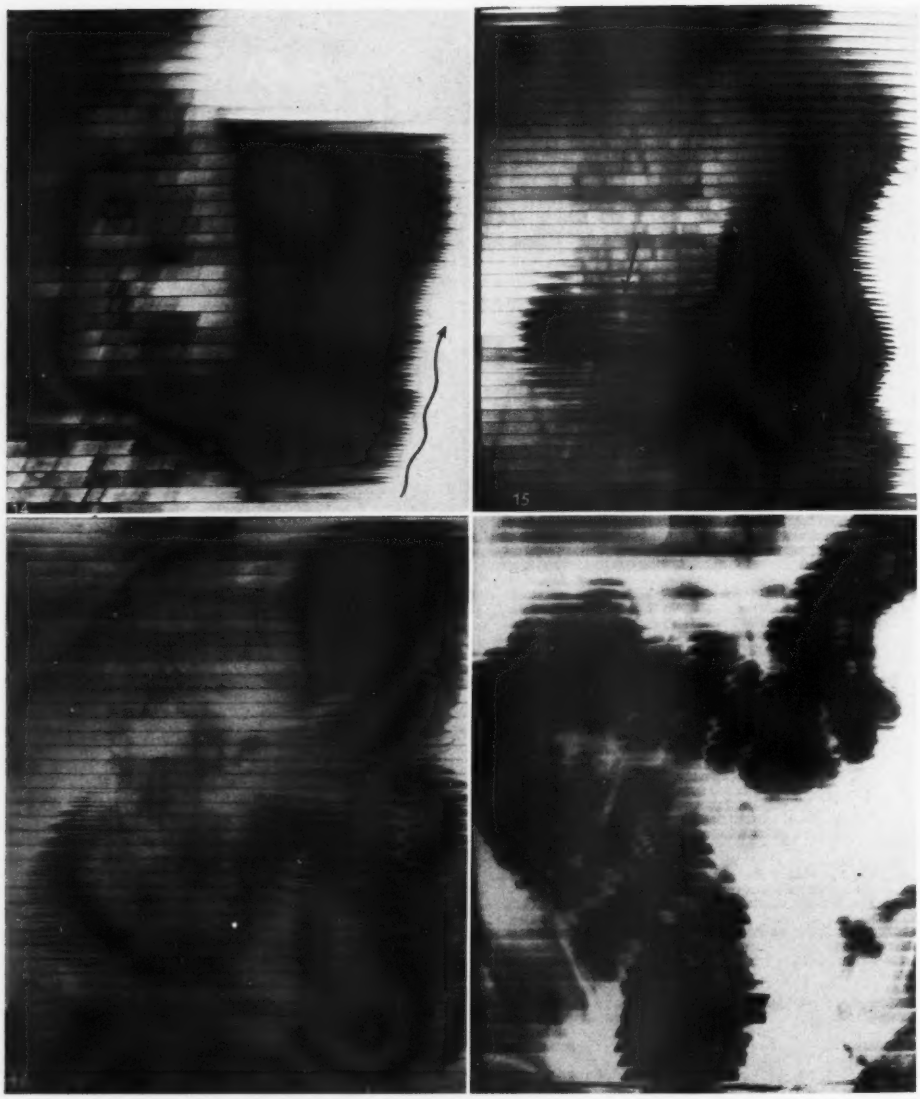

Fig. 14 (*upper left*). In case of carcinoma involving the pylorus we often diagnose retroperistalsis.
Fig. 15 (*upper right*). Small malignant infiltrations show a limited lack of movements. This portion is only passively moved by peristalsis. Arrow shows the position of the small carcinoma.
Fig. 16 (*lower left*). Kymogram of the moving small intestine.
Fig. 17 (*lower right*). Kymogram of the moving large intestine; exposure of three minutes.

In a kymogram of a knee joint during movement, one obtains a flat kymogram, the curves of which are an expression of the movement. If one moves the drum across the field of vision, one interval of time becomes visible. If one-half of the kymogram is covered, when one moves the drum the pictures arrange themselves, and one perceives in the covered portion the impression of movement. In a flat kymogram of respiration, through the movement of the drum one receives the picture of breathing. Each process is reproduced many times in one demonstration. In the flat kymogram

of the movement of the heart, the pointer shows the curves. For the diagnostic evaluation of the cardiac kymogram it is more advantageous to consider the curves around the edge. In myocardial damage (infarct), the appearance of the curves changes at the given place (Fig. 1-*a*). The pointer shows the site of infarction.

When the film is moved the changes in movement are more difficult to recognize than by means of the curves. It is possible to draw the median movement (systole) by means of compasses, which delineate a systole in the cranial portions of the heart chambers and at the same time a lateral movement in the caudal portions. With pericardial changes (concretio-pericardii), the movements of the cardiac borders cease (Fig. 3). A kymogram showing the act of swallowing with a freely moving struma is reproduced in Figure 4. This movement ceases in the presence of mediastinal growths (Fig. 5).

In a flat kymogram (Fig. 6) of a stomach (exposure 60 sec. with 6 ma. and 80 kv.), the demonstration is ten times as fast as the natural process.

Figure 7 shows a film of the movements of the mucosal folds. The folds follow the movements of the borders and show movements away from and toward each other. Figure 8 shows the movements of the folds in gastritis. The folds do not move rhythmically nor in an orderly fashion.

In gastric ulcer (Fig. 9) the niche is passive and there are general disturbances of movement (partial retroperistalsis). In ulcer of the posterior wall (Fig. 10) one sees partial retroperistalsis in the segment of the ulcer. The pointer shows the area of the ulcer. In ulcer of the pylorus (Fig. 11) there is complete retroperistalsis with good emptying of the stomach. In carcinoma (Fig. 12), immobility is a sign of a spread of the infiltration. In carcinoma of the pylorus (Fig. 14) one often sees retroperistalsis. Small carcinomas show a circumscribed immobility which is included in the peristaltic movements (Fig. 15). The movement of the small intestine is often pendular (Fig. 16), and is increased when stimulated. Figure 16 is a reproduction of a flat kymogram of the movements of the small intestine (exposure 15 sec., five times normal speed). The movements of the large intestine are slow; they are not visible in the fluoroscope. The flat kymogram shown in Figure 17 was taken in three minutes with a low current.

CONCLUSIONS

I hope that I have convinced you that the kymogram is a useful aid to diagnosis; that it brings into objective view all movements and that the interpretation of the curves in the stationary film and the observations made in the moving film lead to the grasp of phenomena which escape the usual procedures employed in diagnosis.

The use of the kymographic method in practice is quite simple, since the necessary apparatus has no complicated parts and is based on the principle of moving the film by means of a drum.

The use of materials is small, since all movements may be recorded on one film of ordinary size. It is evident that the study of morphology should never be neglected. Therefore, I have built the apparatus in such a manner that ordinary exposures with and without filters, focused exposures and serial films can be taken without changing anything in the apparatus. The kymograms, therefore, fit in with the usual working methods and do not take any considerable time. They represent an added step toward better diagnosis. Morphology and movement belong together, just as they are indivisible in life.

THE ROENTGENOLOGIC DIAGNOSIS OF TUMORS INVOLVING THE SACRUM[1]

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THE sacrum may be involved by a wide variety of tumors, both benign and malignant. This involvement is often sufficient to produce changes demonstrable in the roentgenogram which at times are characteristic of a particular type of tumor.

Other than instances of metastatic involvement of the sacrum we have observed 41 cases in which involvement of the sacrum by a tumor was demonstrable roentgenologically. In 28, or 68 per cent, of these cases tissue obtained from the tumor was examined by a pathologist.

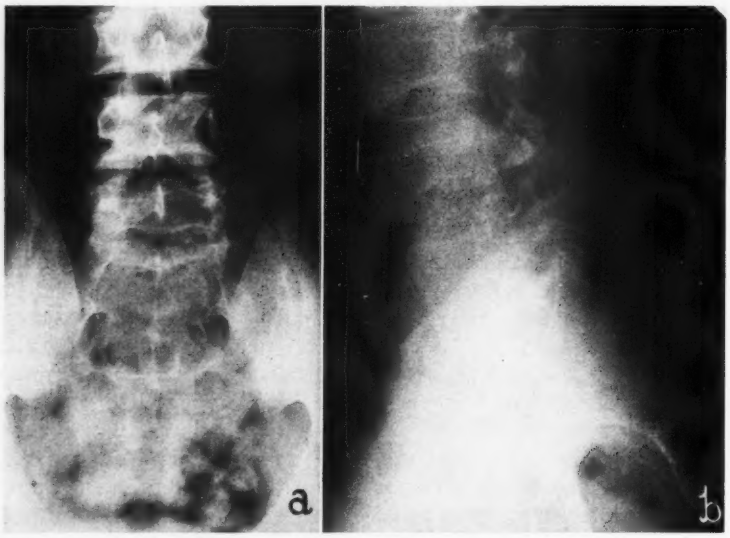

Fig. 1-*A*. Ependymal-cell glioma involving the sacrum and last three lumbar vertebræ; the margins of the sacral defect are sharp and well-defined.
Fig. 1-*B*. Lateral roentgenogram showing the typical expansion of the sacral canal by an ependymal-cell glioma.

The tumors involving the sacrum may be grouped as benign and malignant and may be classified further according to point of origin, as follows: (1) tumors arising within the sacral canal, (2) tumors arising from the body of the sacrum, and (3) tumors arising from structures adjacent to the sacrum.

In general, it may be stated that malignant tumors infiltrate and destroy the sacrum, rendering a diagnosis of malignant disease possible from the roentgenogram alone. Benign tumors, on the other hand, deform the bone but do not invade it. The sacrum may be eroded by pressure from a contiguous benign tumor, but there will be no invasion with subsequent destruction. From the characteristics of the erosion it is often possible to place the tumor in one of the classifications that have been listed. For example, tumors arising within the sacral canal cause erosion which increases the diameter of the canal, as will be discussed later.

[1] Submitted for publication Aug. 23, 1938.

Fig. 2. Fig. 3.

Fig. 2. Neurofibroma of the fifth lumbar nerve on the left side. One may note the erosion of the upper border of sacrum on the left as well as involvement of the fifth lumbar vertebra; the tumor is delineated above by lipiodol in the subarachnoid space.

Fig. 3-*A*. Sacrococcygeal chordoma; destruction of the sacrum is pronounced and remnants of bone may be seen in the soft tissue mass.

Fig. 3-*B*. Lateral roentgenogram showing the expansion of the sacrum in the anteroposterior diameter by a chordoma.

TUMORS ARISING WITHIN THE SACRAL CANAL

In 14 of the 41 cases observed the tumors arose within the sacral canal. Tissue obtained from 11 of these tumors was examined by the pathologist. In the remaining three cases the diagnosis was made on the basis of clinical and roentgenologic findings. Twelve tumors were ependymal-cell gliomas and two were neurofibromas.

The ependymal-cell glioma is the most common tumor arising within the sacral canal. It is derived from the cells lining the central canal of the spinal cord, conus and filum terminale (1). Whereas this tumor is classified as malignant by the pathologist, roentgenologically it resembles a benign tumor. This is probably due to the fact that the tumor is intradural and the dura therefore offers an obstacle to invasion of the surrounding bone and tends to keep the tumor encapsulated. These tumors cause erosion of the sacral canal by expansion and direct pressure; the margins of the eroded bone are sharp and well defined (Fig. 1). The growth may originate at any point in the spinal canal and often attains considerable size. Thus several of the lumbar vertebræ, as well as the sacrum, may be involved. When this is the case, the cartilaginous intervertebral disks, which are resistant to pressure, remain intact. Because of the lobulated

Fig. 4. Ewing's tumor involving the first two sacral segments; the roentgenologic characteristics of malignancy are well shown, but there is nothing typical of Ewing's tumor.

Fig. 5.

Fig. 6.

Fig. 5. Benign giant-cell tumor involving the sacrum; appearance before roentgen therapy.
Fig. 6. Benign giant-cell tumor involving the sacrum (same tumor as shown in Figure 5); appearance following roentgen therapy. One may note regeneration of bone.

character of the tumor the sacrum is often eroded in an irregular manner, which causes a multiloculated appearance.

Roentgenologically, ependymal-cell gliomas must be distinguished from benign giant-cell tumors of the sacrum and from spina bifida occulta. In the former the multilocular cysts are part of the bone itself, whereas the ependymal-cell glioma produces pseudocysts by expansion and erosion of the bony surroundings of the sacral canal. Spina bifida occulta may be confounded with erosion of the laminæ and spinous processes although in the former decalcification that is due to pressure erosion is absent unless a meningocele is co-existent.

Changes similar to those produced by ependymal-cell gliomas are caused by neurofibromas. These tumors arise from the roots of the spinal nerves and may be intradural or extradural. They frequently extend along the course of a nerve and produce a dumbbell-shaped mass which extends both intradurally and extradurally. The erosion of the sacral canal that is produced by a neurofibroma is identical to that observed in the case of the ependymal-cell glioma, but, in addition, erosion of the sacral foramina and even of the external surface of the sacrum may occur (Fig. 2). The margins of the eroded bone also are sharp and well defined.

TUMORS ARISING FROM THE SACRUM

Twenty of the 41 tumors in this series arose from the sacrum. Eleven of these tumors were examined by the pathologist, while the remaining nine were classified according to clinical and roentgenologic findings. These 20 tumors were classified as follows: ten were chordomas; three were sarcomas; one was a benign giant-cell tumor; one was a Ewing tumor, and five were classified as malignant tumors.

In this series of cases the most common tumor arising from the sacrum was the chordoma. This tumor has its origin from remnants of the notocord (2). Roentgenologically, the most characteristic feature of the chordoma is the fact that it usually causes expansion of the sacrum, especially in the anteroposterior diameter (Figs. 3-*A*, 3-*B*), although infiltrative destruction of

the bone is pronounced and furnishes an immediate clue to the malignant nature of the tumor. In some cases remnants of bone are seen to be free in the large soft mass of the tumor. These may be increased in density and may simulate sequestra and even calcification.

In all of the cases of chordoma reviewed it was possible to make a diagnosis of malignant disease of the sacrum. In a few, however, the changes that were apparent in the roentgenograms were insufficiently characteristic to permit a more specific diagnosis.

Hsieh and Hsieh (3) recently reported a study of three cases of sacrococcygeal chordoma. They enumerated the following roentgenologic signs: (1) expansion of the sacrum, (2) destruction, (3) trabeculation, and (4) calcification. In general, their findings agreed with ours.

The roentgenologic appearance of Ewing's tumor of the sacrum is not as characteristic as that of Ewing's tumor of the long bones. The predominant feature is destruction, as is the case of all malignant lesions of the sacrum (Fig. 4). It rarely is possible for the roentgenologist to make a more specific diagnosis than malignant disease from the roentgenologic findings alone. This is also true in most cases of osteogenic sarcoma.

In five of the 20 cases in this group the clinical, surgical, and roentgenologic findings were insufficient to permit a more specific diagnosis than that of malignant disease involving the sacrum.

Benign giant-cell tumor involving the sacrum usually shows the characteristics which it exhibits elsewhere in the skeleton. Trabeculation takes place, together with formation of multiloculated cysts and deformity of the sacral outline (Fig. 5). Regeneration and recalcification of bone occur following roentgen therapy (Fig. 6).

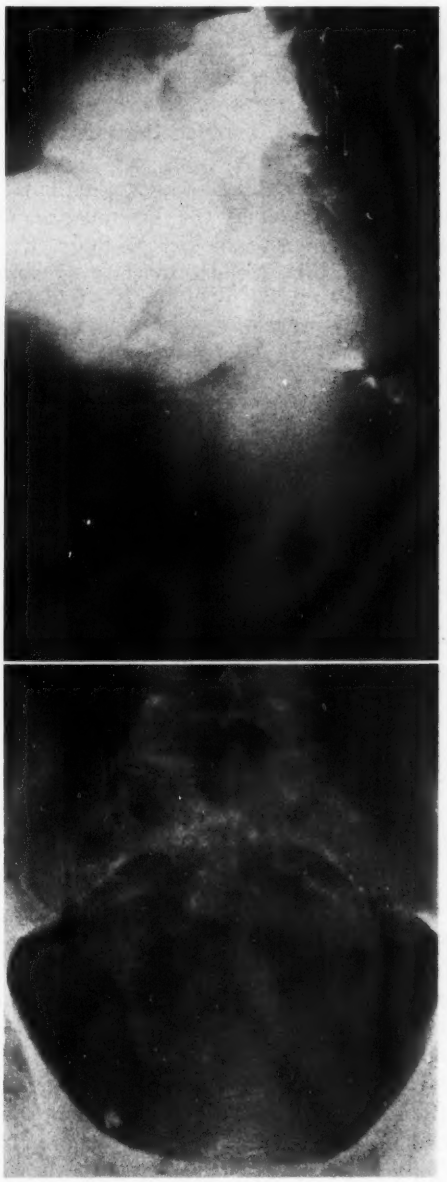

Fig. 7 (*above*). Teratoma arising in front of the sacrum, which has been deformed by the pressure of the tumor; the visible masses of calcification are caused by teeth in the tumor.

Fig. 8 (*below*). Metastatic carcinoma involving the sacrum; the primary site was in the prostate gland.

TUMORS ARISING FROM STRUCTURES ADJACENT TO THE SACRUM

In seven of the 41 cases reviewed the tumors arose from structures adjacent to the sacrum and involving it because of its proximity. In six of these cases the tumors were examined by the pathologist, while in one case the diagnosis was made by

a combination of clinical and roentgenologic data. In four of the seven cases the tumors were called teratomas, while in the other three cases there were malignant tumors that had involved the sacrum secondarily.

In the three cases in which a malignant tumor had involved the sacrum secondarily the roentgenologic findings were similar in every respect to those encountered in other cases of malignant involvement of the sacrum, whether the involvement was primary or secondary. It is impossible for the roentgenologist to predict the origin of the tumor in more than a very few instances; the only permissible diagnosis is malignant disease of the sacrum.

The teratomas were remarkable because of the extensive deformity of the sacrum which often was associated with these tumors. Erosion of the anterior or posterior surface of the sacrum may be present as a result of pressure. Occasionally, calcification or the formation of a tooth is noted in the soft tissue mass (Fig. 7).

Teratoma must be distinguished from meningocele and spina bifida. In a case of teratoma there is decalcification of the eroded surfaces, while the separation of the laminæ is clearly defined in cases of spina bifida or meningocele.

The lesions that most frequently simulate tumors involving the sacrum are metastatic carcinoma (Fig. 8), multiple myeloma, and osteomyelitis. The first may be distinguished by identification of a primary tumor, or by the presence of involvement of other portions of the skeleton. Multiple myeloma is a disease of more than a single bone, and usually may be distinguished by involvement elsewhere in the skeleton, especially of the ribs, skull, and vertebræ. In one case in this series, however, the sacrum was involved by an infiltrating malignant tumor which caused some expansion of the bone, especially in the anteroposterior diameter (Figs. 9-*A* and 9-*B*). No other skeletal involvement was noted. A diagnosis of myeloma was made by the clinician because of the presence of Bence-Jones protein in the urine.

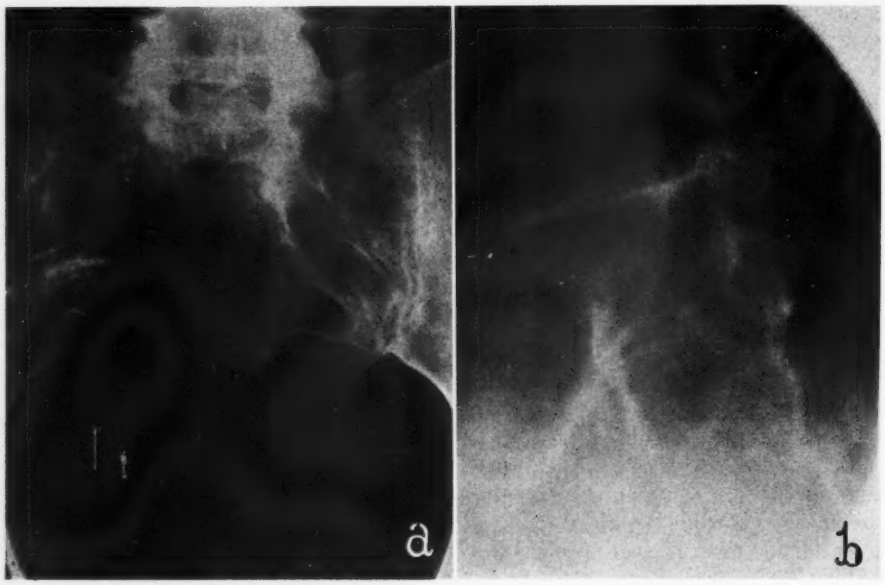

Fig. 9-*A*. Atypical involvement of sacrum by multiple myeloma.
Fig. 9-*B*. Lateral roentgenogram of sacrum.

Examination two years later disclosed involvement of ribs and vertebræ which was typical of multiple myeloma.

Osteomyelitis, because of its inflammatory nature, generally causes a certain amount of reaction in the surrounding bone. It usually begins in or near the sacro-iliac joint and may often be distinguished clinically.

SUMMARY

Exclusive of metastatic processes, tumors involving the sacrum may be classified according to point of origin as follows: (1) tumors arising within the sacral canal; (2) tumors arising from the body of the sacrum, and (3) tumors arising from structures adjacent to the sacrum. The most common tumor arising within the sacral canal is the ependymal-cell glioma. This tumor causes erosion of the sacral canal by expansion and direct pressure. The margins of the eroded bone are sharp and well-defined. Similar changes, which often are associated with erosion of a sacral foramen, are caused by neurofibromas. The most common tumor arising from the body of the sacrum is the chordoma. The most characteristic feature of the changes produced by a chordoma is the expansion of the sacrum by an infiltrative destructive process. It is often impossible to make a more specific diagnosis than "malignant tumor involving the sacrum" in cases of sarcoma, Ewing's tumor, metastatic carcinoma, and multiple myeloma. Teratomas are usually characterized by deformity or erosion of the sacrum by an extrinsic mass, in which may be seen teeth or calcification.

REFERENCES

(1) CAMP, J. D., ADSON, A. W., and SHUGRUE, J. J.: Roentgenographic Findings Associated with Tumors of the Spinal Column, Spinal Cord, and Associated Tissues. Am. Jour. Cancer, **17,** 348–372, February, 1933.

(2) FLETCHER, ELEANOR M., WOLTMAN, H. W., and ADSON, A. W.: Sacrococcygeal Chordomas; A Clinical and Pathologic Study. Arch. Neurol. and Psychiat., **33,** 283–299, February, 1935.

(3) HSIEH, C. K., and HSIEH, H. H.: Roentgenologic Study of Sacrococcygeal Chordoma. RADIOLOGY, **27,** 101–108, July, 1936.

LEAD RADON TUBULES IN THE TREATMENT OF CARCINOMA OF THE TONGUE[1]

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IN previous articles (1) we have described lead radon tubules together with the dosage and technic which we use in carcinoma of the tongue. In the present paper we shall review our methods and discuss the results obtained in a group of unselected consecutive cases.

In the treatment of malignancy we believe one should not be prejudiced in favor of radium or surgery, but should give patients the benefit of both methods solely with the idea of obtaining the best and most permanent results. In most clinics where expert surgery and all the resources of radium are equally available, radium has largely superseded surgery in carcinoma of the anterior two-thirds of the tongue. When the lesion is very small and situated near the tip of the tongue, excision may be preferred by some. With lesions of the posterior third of the tongue, excision has been practically abandoned by all in favor of radium.

If lesions are subjected to excision, we believe it would be greatly to the patient's advantage if preliminary surface radium treatment to reduce infection and shrink the neoplasm were given by the method about to be outlined. We are opposed to attempted excision of the primary lesion with the idea of following it by radium treatment. The previous removal of a portion of the substance of the tongue takes away muscular and connective tissue necessary for the normal radium reaction. Few appear to realize the harm that may be done by incompletely excising the primary lesion and then trying to cure it with radium when the tumor bed has been irreparably damaged.

General Care of the Patient.—A general examination, including roentgenograms of the chest and jaws, is desirable. Success in radium therapy of carcinoma of the tongue depends largely on careful attention to a chain of details. Examination of the oral cavity should be thorough but nontraumatic. We believe it is best not to disturb the tongue by any sort of manipulations within the mouth, such as the extraction of teeth, except in emergencies. Physiologic rest of the tongue is desirable. Talking should be limited and all traumatisms, such as pulling on the tongue, squeezing, rubbing, or cauterizing the lesion, should be avoided.

We advise against irrigations for purposes of disinfection, believing that the surface radium applications about to be described are immeasurably more efficient.

Indications for Radium "Puncture."—In the treatment of the primary lesion, surface applications of radium, although invaluable as an adjunct, have been generally

TABLE I.—SQUAMOUS-CELL CARCINOMA OF TONGUE

No. patients	39	
Age		
Average	57 years	
Oldest	80 years	
Youngest	30 years	
Sex	No.	Percentage
Males	31	79.5
Females	8	20.5
Syphilis: Definite history and Wassermann positive	3	
Temporary resolution of tongue lesion with recurrence in tongue and neck	2	
Tongue lesion was not eradicated	1	

TABLE II.—SITE OF LESION

	No.	Percentage
Anterior two-thirds of tongue	21	53.8
Posterior third of tongue	10	25.6
Major part of tongue	8	20.5
Size of lesion	Centimeters	
Diameter of largest lesion	7	
Diameter of smallest lesion	2	
Average diameter of all lesions	3.7	
Average diameter of cured lesions	3.6	
Average diameter of lesions not cured	4.2	

[1] Presented before the Fifth International Congress of Radiology, at Chicago, Sept. 13–17, 1937.

TABLE III.—PATHOLOGIC TYPE OF LESION (BRODERS' CLASSIFICATION)

	No.	Percentage
Grade 1	4	10.2
Grade 2	14	35.9
Grade 3	9	23.0
Grade 4	1	2.6
Cases not graded	11	28.2
Total	39	
Clinical Cures		
Grade 1	3	
Grade 2	3[1]	
Grade 3	4	
Grade 4	1	
Cases not graded	4[2]	
Total	15	38.5
Clinical Failures		
Grade 1	1	
Grade 2	11[3]	
Grade 3	5	
Grade 4	0	
Cases not graded	7	
Total	24	61.5

[1] Patient, aged 40, died of double pneumonia four and one-half years after treatment; clinically free of carcinoma.

[2] Patient, aged 83, died of pneumonia three years after treatment; clinically free of carcinoma.

[3] Patient, aged 71, living two years after treatment; has metastasis in neck.

TABLE IV.—LYMPH NODES OF NECK PALPABLE AT BEGINNING OF TREATMENT

	No.	Percentage
Cervical nodes	26	
Cervical and submaxillary nodes	3	
Cervical and submental nodes	3	
More than one group of nodes	6	
Total cases with nodes	26	66.6
Total cases without nodes	13	33.3

TABLE V.—RESULTS OF TREATMENT OF 26 CASES WITH NODES

	No.	Percentage
Dead	20	76.9
In poor condition	1	3.8
Clinically well	5	19.2

found inadequate to accomplish a clinical cure. It is usually necessary, therefore, to resort to radium "puncture." Formerly we believed the primary lesion should not be subjected to "puncture" in the presence of evident metastases. We now believe that conservative radon "puncture" may be used for palliation even though metastases are present.

For the best results the operator should be equipped with a sufficient amount of radium and a laboratory for the preparation of radon tubules. Success or failure depends on the nature and stage of development of the tumor; on the type of radium therapy used; to some extent on other factors, such as the presence of syphilis or diabetes, which influence the prognosis unfavorably.

Methods of Implantation (Radium "Puncture").—Two types of needles or tubules containing radium or radon have been used—the removable and the permanent. We do not favor removable needles or "seeds" because of their large size, the traumatism from the attached threads which may be sewed into the tongue, the possibilities of increased infection, and various other reasons. We have also abandoned the use of both glass and gold tubules which may be permanently implanted in the tongue. Glass tubules are efficient but cause unnecessary pain and reaction. Gold tubules, left permanently in the tongue, may cause residual pain, lasting almost indefinitely, due to the intolerance of the tissues to gold.

Lead Tubules.—In 1930 we began to use, for puncturing certain carcinomatous lesions, radon tubules made of capillary lead tubing. We chose lead as a jacket for radon because, from surgical experience with ordinary "lead bullets," we believed lead tubules would be well tolerated even if they remained permanently in the tissues. Later we incorporated antimony in the lead tubing in the proportion of 5 per cent in order to harden it. For convenience, we refer to these tubules as "lead" instead of "lead-antimony."

Preparation of Lead Radon Tubules.—The proper preparation of lead tubules in the laboratory is the foundation of success. We estimate the number of tubules that will probably be required and then make at least one-half more than the estimated number. Nothing is more disastrous than to run short of tubules after the operation has been started. The tubules are made by sealing the desired length of capillary

lead tubing to the terminal glass capillary of the radon machine; filling the tubing with a sufficient amount of radon gas, and cutting off the whole lead tubing with a special forceps. The lead tubing containing the radon gas is then cut into the proper number of tubules with the special forceps, which seals the ends of each tubule at the same time. In effect, a cold weld of the metal is formed. We usually make the tubules slightly stronger than desired and allow them to decay until each tubule contains approximately 0.5 mc. It is very important that the radon tubules, collectively and individually, be tested with the electroscope several times in the 48 hours preceding implantation, on account of the rapid decay of leaking tubules. The length of the tubules is from 2 to 3 mm.; wall thickness, 0.3 mm.; internal diameter, 0.15 mm.; radon content, 0.5 mc. each. In actual practice the radon content varies slightly. These tubules transmit the gamma rays and approximately 2 per cent of the primary beta rays.

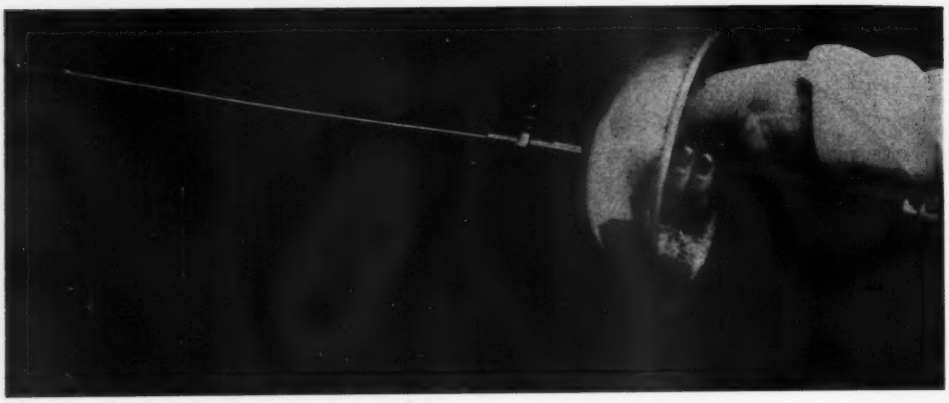

Fig. 1. Bell-shaped guard for protection of operator's hand during surface irradiation. To the distal end, the radon screen, containing from 500 to 1,000 mc. of radon, may be attached.

Fig. 2. Instrument for implanting lead radon tubules.

Beta rays have been estimated to be

eight to ten times as lethal to the cancer cell as gamma rays. We believe that a certain amount of beta rays and a moderately sharp reaction are not undesirable in carcinoma of the tongue.

Technic of Surface Treatment.—We begin the treatment of the tongue lesion by applying daily or twice daily, for approximately five minutes, from 500 to 1,000 mc. in close contact with the lesion. The radon is screened with 2 mm. of silver and sufficient rubber so that the glass radon tubes are exactly 6 mm. distant from the lesion. Great care must be used not to rub or manipulate the lesion.

For protection of the body from the gamma rays, the operator stands or sits behind a heavy lead angle plate. For the protection of the operator's hand, we have devised a bell-shaped guard (Fig. 1) similar to a fencing foil guard. To the distal end of the bell-shaped guard, which is covered with one-fourth of an inch of lead, is attached a flexible copper wire 12 inches long and one-eighth of an inch in diameter. The screen containing from 500 to 1,000 mc. of radon is attached to the distal end of the copper wire.

Approximately from 250 to 300 mc.-hr. may be given to a single area. Dosage varies, however, with the amount of elevation of the carcinoma above the level of the tongue, so that it is difficult to lay down definite rules.

The importance of these preliminary surface irradiations in reducing infection and delimiting and shrinking the neoplasm can hardly be overestimated. We have also entertained the hope that carcinoma cells lying near the surface may be devitalized, thus making radium "puncture" safer from the standpoint of metastasis.

Biopsy.—A few days after surface irradiations have been begun, we carefully biopsy the lesion with a sharp knife. We do not apply caustics to the biopsied area because of the well-known stimulating effect of caustics on carcinoma. It seems logical to believe also that a little free bleeding after biopsy may wash out loose carcinoma cells.

TABLE VI.—RESULTS OF TREATMENT OF 13 CASES WITHOUT NODES

	No.	Percentage
Dead	5	38.4
Clinically well	8	61.5

TABLE VII.—RESULTS TO MAY 1, 1937, IN 39 CASES: 26 CASES WITH AND 13 CASES WITHOUT NODES

	No.	Percentage
Dead of carcinoma	23	58.97
In poor condition	1	2.56
Clinically well of carcinoma, one over four years and one over three years, but died later of intercurrent disease	2	5.12
Clinically well	13	33.33

TABLE VIII.—DURATION OF LIFE AFTER TREATMENT IN 25 CASES THAT DIED

	No.
Lived over 5 years	0
Lived over 4 years	1
Lived over 3 years	1
Lived over 2 years	3
Lived over 1 year	7
Lived less than 1 year	13
Total	25

Technic of Radon "Puncture."—Having prepared the "soil" by preliminary surface irradiations, the lead radon "seeds" may be implanted. The utmost gentleness should be used in dealing with the carcinomatous tongue. Pulling on the tongue, squeezing, or rough sponging of the lesion should be avoided. We prefer to block the lingual nerve rather than to use general anesthesia.

For the implantation of tubules we have devised a small instrument (tubule introducer), a description (2) of which was published in 1922 (Fig. 2). This instrument is constructed on the plan of an ordinary syringe. Needles of different lengths and curves may be attached to the distal end of the instrument. The lead tubules are inserted into the distal end of the needle and dislodged by an obturator which slides in the lumen of the needle. Ordinarily two tubules may be implanted at each puncture. While regard must be paid to the peculiarities of the individual lesion, our

general plan is to implant the tubules in the shape of a truncated cone, the smaller end of the cone lying toward the surface. "Stabbing" the lesion with the needle of the introducer is to be avoided. The point of the needle containing the radon seeds should be placed carefully on the surface of the tongue and pushed gently inward to the desired spot. The needle may then be withdrawn a few millimeters and the tubules gently deposited by means of the obturator in the minute cavity created.

Fig. 3.

Fig. 4.

Fig. 3. Carcinoma of the tongue before treatment.
Fig. 4. Same patient after radium treatment. Living and clinically well over three years.

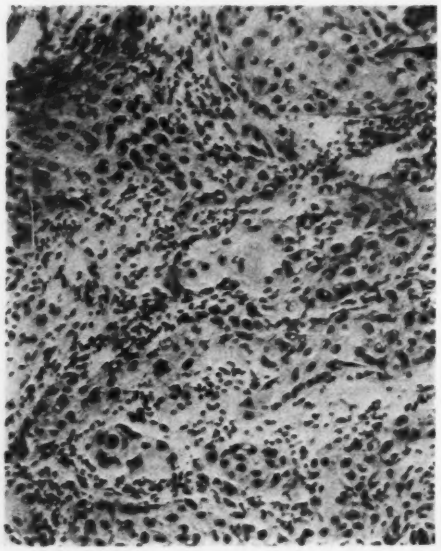

Fig. 5. Photomicrograph of section of lesion in Figure 3. Magnification 150 ×.

For lesions far back in the tongue, we use curved needles by means of which the affected area can be implanted from the mucous membrane surface, with the aid of a laryngeal mirror. For posterior lesions, we have not used the method suggested by different authors of nicking the skin in the submental region and pushing implantation needles into the incision until they engage in the carcinoma, because we fear that while withdrawing the needles along a tract of healthy tissue, transplantation of cancer cells may occur. We regard it as very important to use a fresh sterile needle and obturator for each puncture in order to obviate the possibility of transplanting cancer cells or introducing additional infection.

We have found it convenient to slip a small sliding guard, or metal node, over each needle used for implantation. This contrivance, known as a "cravat pin guard," may be obtained in any haberdashery. By means of this guard, the distance from the end of the needle in centi-

meters and therefore the depth below the surface that each tubule is implanted, can be accurately measured. It is, perhaps, needless to say that the tubules are sterilized by dipping them successively in 95 per cent carbolic acid, alcohol, and ether.

TABLE IX.—CAUSE OF DEATH IN 25 CASES

	No.
Carcinoma	22
Heart disease (two weeks after treatment)	1
Lobar pneumonia	2
One died over four years after treatment; one died over three years after treatment; both clinically free of carcinoma at time of death.	

TABLE X.—CLINICAL CONDITION OF 14 CASES THAT ARE LIVING

	No.	Percentage
Well over 6 years	4	28.5
Well over 4 years	1	7.4
Well over 3 years	3	21.4
Well over 2 years	4	28.5
Well over 1 year	1	7.4
Living over 2 years but in poor condition	1	7.4
Total	14	

We usually draw a clock-faced diagram of the lesion and mark on the diagram the estimated points of insertion. After the routine implantation, one can go over the lesion and implant additional tubules at strategic points. The general rule of implanting approximately 1 mc. to each cubic centimeter of carcinomatous tissue has been followed. With small lesions, however, we deliberately overdose the lesion and the surrounding tissues; with large lesions, caution must be used not to give an excessive dose on account of the danger of severe radium necrosis. At the present time we seldom use less than a total of 15 mc. (30 tubules) or more than 35 mc. (70 tubules) in a single lesion.

Some of the advantages of lead radon tubules are: (1) there is no mortality due to the implantation; (2) hospitalization is seldom necessary; (3) there is less pain and discomfort than after most other methods; (4) sewing threads into the tongue is obviated; (5) recurrence in the tongue in our experience is less frequent than after the use of removable needles; (6) no residual pain due to the permanent presence of lead tubules in the tissues has been observed.

Fig. 6. Roentgenogram of patient in Figure 3 showing 25 lead radon tubules remaining permanently in tongue.

Metastases.—The difficulty of obtaining a clinical cure in carcinoma of the tongue lies not so much in the primary lesion as in the development of metastases.

Non-palpable Nodes of the Neck.—Some advocate block dissection in all operable cases; others do not operate in the absence of evident metastases. We use routine radium bomb treatment although we are not opposed to routine block dissection in dealing with ordinary squamous-cell carcinoma.

TABLE XI

Clinical record: Male, aged 69, first examined Jan. 9, 1935; severely ulcerated tongue lesion; right cervical nodes enlarged.

Result: Permanent resolution of tongue lesion; living but in poor condition from persistence of cervical metastasis.

Largest diameter of tongue lesion in cm.	Biopsy	No. tubules implanted in tongue lesion	Average strength of tubules in mc.	Total mc. implanted in tongue	Radium bomb to neck
7	Squamous-cell carcinoma Grade 2	100	0.48	48	28,000 mc.-hr. to neck at from 4 to 6 cm.

TABLE XII

Average size of tongue lesion and amount of treatment in seven cases: six with nodes, one without nodes; failure to eradicate tongue lesion; death from metastasis. One patient of this group had syphilis.

Average diameter of tongue lesion in cm.	Average no. of lead tubules implanted	Average strength of tubules in mc.	Average total mc. implanted in tongue	Radium bomb to neck
5	50	.67	33.5	Average 30,000 mc.-hr. at from 4 to 6 cm.

TABLE XIII

Average size of tongue lesion and amount of treatment in four cases: three with nodes, one without nodes; temporary resolution of tongue lesion with recurrence; death from metastasis. Two patients of this group had syphilis.

Average diameter of tongue lesion in cm.	Average no. of lead tubules implanted	Average strength of tubules in mc.	Average total mc. implanted in tongue	Radium bomb to neck
5	39	0.74	28.8	Average 26,000 mc.-hr. at from 4 to 6 cm.

TABLE XIV

Average size of tongue lesion and amount of treatment in 12 cases: 11 with nodes, one without nodes; permanent resolution of tongue lesion; death from metastasis.

Average diameter of tongue lesion in cm.	Average no. of lead tubules implanted	Average strength of tubules in mc.	Average total mc. implanted in tongue	Radium bomb to neck
5	38	0.71	26.9	Average 26,000 mc.-hr. at from 4 to 6 cm.

TABLE XV

Average size of tongue lesion and amount of treatment in two cases, both without nodes; permanent resolution of tongue lesion; one patient lived over four years, one over three years; death later from intercurrent disease; both clinically free of carcinoma.

Average diameter of tongue lesion in cm.	Average no. of lead tubules implanted	Average strength of tubules in mc.	Average total mc. implanted in tongue	Radium bomb to neck
	50	0.67	33.5	Average 24,000 mc.-hr. at from 4 to 6 cm.

TABLE XVI

Average size of tongue lesion and amount of treatment in 13 cases: five with nodes, eight without nodes; permanent resolution of tongue lesion and clinical recovery.

Average diameter of tongue lesion in cm.	Average no. of lead tubules implanted	Average strength of tubules in mc.	Average total mc. implanted in tongue	Radium bomb to neck
3	37	0.5 to 0.6	20.3	Average 24,000 mc.-hr. at from 4 to 6 cm.

Palpable Nodes of the Neck.—Surgical and radiological opinion appears to be greatly influenced by the type of carcinoma. With squamous-cell carcinoma with cell nests, excision is favored; with lympho- or transitional-cell epithelioma, irradiation is preferred. The results of excision, however, in cases in which nodes other than one submaxillary node are involved are not encouraging. If irradiations are used, we advocate surface irradiations with the radium bomb. There is some evidence indicating that a combination of radium and x-rays applied to the surface is superior to either agent used alone.

Technic of Radium Treatment of Lymph Nodes of the Neck.—Only surface irradiations are used: we do not favor radium or radon "puncture" of carcinomatous lymph nodes. At a distance of from 4 to 6 cm., the radium "bomb" containing a minimum of 1,000 mc. screened with 2 mm. of silver and from 4 to 6 cm. of balsa wood, may be applied daily. In the course of from four to six weeks from 24,000 to 36,000 mc.-hr. may be given to a skin area of 64 sq. cm. We avoid severe skin reactions whenever possible.

As we pointed out in 1926 (3), unless nodes are examined microscopically there is no absolute certainty that they are carcinomatous. Palpable nodes that resolve completely under irradiation we always regard as inflammatory in the absence of microscopic evidence to the contrary.

Results.—From May 1, 1930, to May 1, 1936, we treated by the method outlined, 39 cases of carcinoma of the tongue which were diagnosed clinically and microscopically. Every case was treated without regard to statistics, but solely with the idea of relieving the patient. We would especially emphasize the fact that sufficient time has not elapsed to claim a permanent result except in a small proportion of cases. The results of treatment up to May 1, 1937, are noted in the accompanying tables.

For much help in the preparation of this paper, especially in connection with radon measurements and statistics, I wish to express my grateful thanks to my associates, Dr. J. E. Breed and Dr. J. S. Thompson.

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BIBLIOGRAPHY

(1) SIMPSON, F. E., and THOMPSON, J. S.: Lead-antimony Ampules Containing Radon for Implantation in Cancer. Am. Jour. Surg., **15,** 256–258, February, 1932.

SIMPSON, F. E.: Radium Dosage and Technic in Carcinoma of the Tongue. Am. Jour. Roentgenol. and Rad. Ther., **34,** 63–68, July, 1935.

Idem: Treatment of Cancer of the Tongue with Radium. Radiol. Rev. and Miss. Valley Med. Jour., **58,** 86–91, May, 1936.

(2) Idem: Radium Therapy, C. V. Mosby Co., 1922, p. 153.

(3) Idem: The Treatment of Intra-oral Cancer with Radium Emanation. Acta Radiologica, **7,** Fasc. 1–6, No. 35–40, 1926.

ROENTGENOGRAPHY OF THE SECOND CERVICAL VERTEBRA BY OTTONELLO'S METHOD

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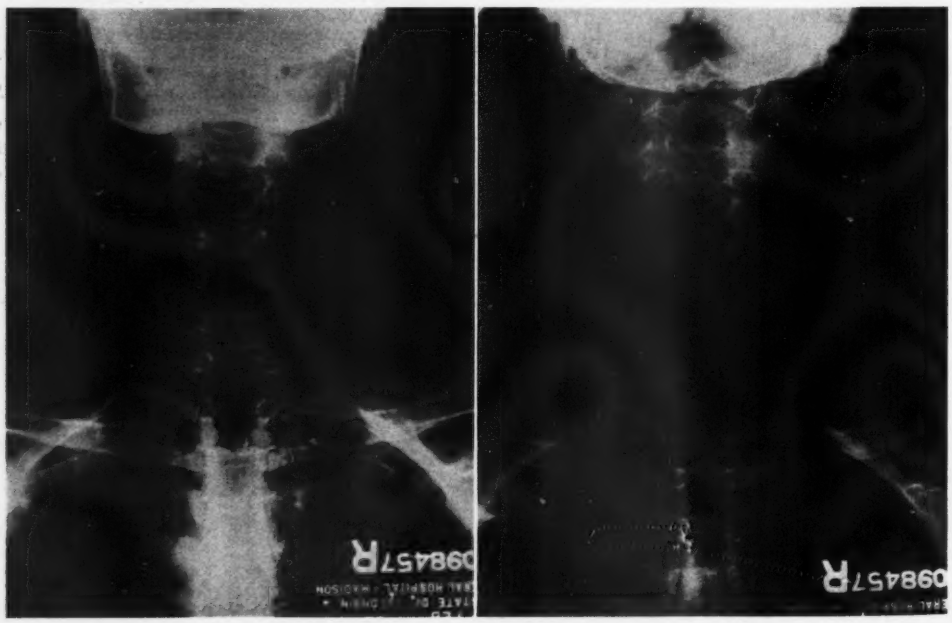
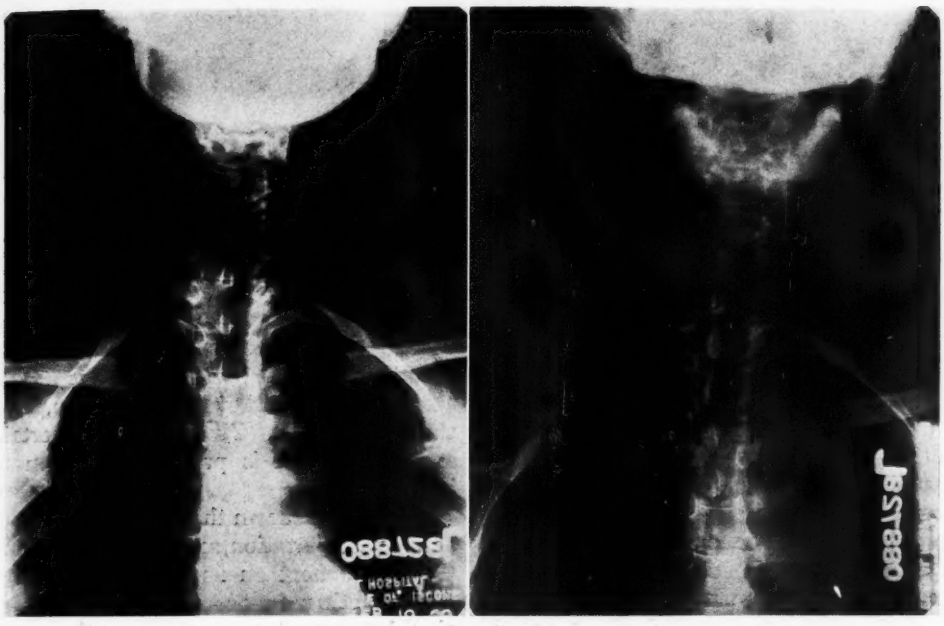
SINCE the description, in 1930, of a method of producing roentgenograms of the entire cervical spine in posterior projection on a single film by Ottonello (1), no information on its use was found in a search of the American literature. As, however, the value of this procedure is considerable, a brief descriptive note, with some suggested modifications, seems warranted.

Ottonello's view consists of a roentgenograph taken with the jaw in constant motion vertically, *i.e.*, by opening and shutting the mouth, the other factors being approximately the same as for the ordinary posterior view of the cervical spine. Several complete motions of the jaw must be made, open and shut, during the exposure, and an even, rhythmical motion is essential. In positioning the head, hyperextension of the neck is very important. If the head is flexed, the upper teeth will prevent the proper visualization of the topmost vertebræ. The study is best made in the recumbent position, with as great an F.S.D. as possible. In order to secure enough blackening of the film through the mandible, it is necessary to double the usual exposure, preferably by raising the voltage. This necessitates over-exposure of the remainder of the film, but two methods are available (not described in Ottonello's original communication) to minimize this. The best of these is to place a pure gum rubber bag filled about two-thirds full of water behind the shoulders and lower neck. It is essential that the bag shall not overlap the jaw in the lowest part of its excursion, as this will produce a blank strip across the film. The filtration of the bag will de-



Figs. 1 and 2. Roentgenograms of a cervical spine by the ordinary technic and by Ottonello's technic.



Figs. 3 and 4. Another pair showing less perfect visualization of C2 on the Ottonello view, due to incomplete extension of the head.

crease the exposure of the film in the lower cervical area enough to produce a satisfactory visualization. Another means of overcoming the difficulty is to use a filter, the upper third of which is 1 mm. Al, the second third, 2 mm., and the lower third, 3 mm. This is oriented with the thin part over the upper end of the spine. It will accomplish about the same thing as the water bag, but is not, of course, so plastic and is therefore less adaptable. The study is best made stereoscopically, and should, of course, be accompanied by a lateral projection.

With this method it is possible to show the second cervical vertebra and all vertebræ below it on the one film. In the writer's experience only the lower portion of the atlas and the dens are generally demonstrated; the upper portion of the atlas is almost never shown; sometimes the dens may also be obscured.

Routine employment of this method should be satisfactory whenever there is time available for careful positioning and drilling of the patient; but in a very busy department it will be found less satisfactory, as considerable care is needed to produce uniformly good roentgenograms. As a supplementary examination, however, the study has certain points of superiority to the usual view through the open mouth. It can be employed with patients in whom the jaw cannot be widely opened, as required for the open-mouth technic. It gives a single view of the articulation of C1, C2, and C3 not to be obtained by the open-mouth study. It is also employable when the neck cannot be moved for positioning (as after trauma) to a greater extent than can other procedures.

The assistance of Dr. J. B. McAneny in checking the literature, and of Mr. Dudley Slauson in preparing the roentgenograms for reproduction, is gratefully acknowledged.

REFERENCE

(1) Ottonello, Pietro: New Method for Roentgenography of the Entire Cervical Spine in Ventrodorsal Projection. Riv. di Radiol. e Fis. Med., 2, 291–294, March, 1930.

SENSITIZATION TO X-RADIATION BY THE DIRECT ELECTRIC CURRENT

By JOHN RUSSELL CARTY, M.D., *New York City*

IN a previous communication we discussed and reviewed the literature on artificial tissue sensitization to x-radiation. In addition, a preliminary report was made of some experimental work regarding the effects of ionization of irradiated tissue. These experiments have now been completed, and in view of the growing interest in artificial sensitization, it was felt the results might be of interest.

In order to fully comprehend the interaction of two essentially caustic agents on living tissue it is necessary to study the action of each agent alone. The action of the direct electric current may vary from a barely perceptible reaction to complete destruction of normal tissue. Generally speaking, it is quite possible to pass current through living tissue without any demonstrable permanent change whatsoever, as is well known to the physiotherapist. The physico-chemical effects vary greatly at the opposite poles. For instance, the negative pole has an alkaline reaction, vasodilatation takes place, and there is irritation. At the positive pole there is an acid reaction and vasoconstriction, and there is sedation. Production of a certain amount of heat is probably common to both poles.

Fig. 1. Histological study of electric burn. Note the dark necrotic tissue with normal tissue above. This illustrates why an electric burn may be more serious than would be indicated on physical examination. Every precaution was taken during the experimental work to avoid the production of an electric burn.

It has been shown that alkaline reaction, active vasodilatation, and irritation enhance the x-ray effect on normal living tissues. Acid reaction, vasoconstriction, and sedation, however, tend to decrease the effect.

If the current flux per unit tissue area is excessive, a burn may result. The electric current tends to travel where resistance is the least, *i.e.*, along blood vessels, lymphatic channels, etc., sometimes selecting structural planes in a manner which may be compared to that of a sandwich. For this reason an electric burn may actually be quite severe without much outward manifestation. The appearance of an electric burn complicates the evaluation of data tremendously, and every precaution was taken to avoid it. An electric burn is seen immediately after the electrode is removed. If at the negative pole, there is a soft wet eschar which is usually reddish. Under the positive pole the eschar is hard and dry, and is usually white in color. The histology is that of a necrotic process; the tissues taking the basophilic portion of the stain. The lesion usually begins to heal early, and results in a fairly insignificant scar. Unless the current has been very large the general health of the animal was unaffected.

If x-radiation alone is used, on the other hand, there is erythema, epilation, scaling, and ulceration if the dose is large. The

histological changes are those of necrosis directly under the ulcer with fibrosis, endarteritis, etc. The necrosis is not of the selective character often noted with an electrical burn. The general health of the animal is affected, particularly if the treatment is over the abdominal wall.

In estimating the effect of combining the two agents, both gross and histological criteria were used. In the gross study the time of appearance of reaction, intensity of erythema, epilation, scaling, and ulceration were particularly noted. The general health of the animal was also considered. In the histological study, necrosis, fibrosis, cellular swelling, and endarteritis were looked for particularly.

Details of Experiments.—Large Belgian hares were used, and, with a few exceptions, the abdominal wall was chosen for the experimental area. The latter was shaved carefully, avoiding nicks in the skin. If a nick occurred it was covered with collodion. The electric current was derived from 110-volt direct current lighting circuit. Voltage and milliamperage were controlled by a circular graphite, continuous resistance rheostat in series with a 16-watt 110 volt lamp. A milliammeter reading zero to 10 and a voltmeter reading zero to 120 were placed in the output circuit. The electrode consisted of platinum gauze or wire surrounded by surgical gauze moistened in isotonic saline solution. In this manner possible confusing effects due to polarization were avoided. X-radiation was generated by pulsating outfits, one of which had a mechanical rectifier and the other a valve rectification (full wave). Target distance was 20 cm., using unfiltered radiation. Means were taken to dissipate the heat emitted from the target. Intensity measurements were made in air with a Victoreen r-meter which had been checked against a large chamber instrument.

A protocol typical of each group of experiments will be given.

An area on the abdominal wall of the rabbit was prepared. The entire area was irradiated until 2,000 r units were given over the upper half; the positive pole was then placed over the upper half of the area, the lower serving as a control. A current of 5 milliamperes at 30 volts was passed for 45 minutes. Immediately after removal of the electrode there was no evidence of ulceration but there was vasodilatation. Two days after irradiation a soft ulcer was noted where the negative pole had been applied.

Fig. 2. Note the shaved area on the abdomen. The negative electrode was placed on the upper half of the area immediately after the entire area had been irradiated with x-ray 45 days previously. Note the marked reaction under the electrode. The x-ray reaction on the control area is barely visible.

Fig. 3. Longitudinal section from the margin of the sensitized area through the control area, of animal shown in Figure 2. The limits of the negative electrode are indicated by the margin of the necrosis on the right. Note the marked fibrosis in the mid-portion of the section, with less pronounced post-radiation findings to the left.

7 days—marked reddening about the edge of eschar and extending slightly beyond the limits of the electrode. The control appeared normal.

14 days—several scaly patches appeared in the reddened area. The control was normal. Animal showed emaciation and toxicity.

48 days—eschar started to heal, the control showing a slight reddening.

60 days—scar had formed with a hard mass in the subcutaneous tissue under the scar. The control appeared normal.

The experiment was repeated with the ionization given before, and then during, the irradiation. Ionization with the positive pole was then done under the above experimental conditions.

In order to demonstrate the effect of intensity of current flow, the flowing experiment was completed:

An electrode consisting of a platinum wire in contact with several layers of surgical gauze was placed across the end of the right ear of a rabbit to form a positive pole. The gauze was moistened with normal saline solution. A large dispersive electrode was placed on the back. The left ear served as a control and the end was similarly clamped between tongue depressers. This was done to avoid errors which might be caused by blocking of the venous flow. Four milliamperes at a voltage of 30 was passed through the ear for four minutes before irradiating. X-radiation was then applied for 25 minutes while the current was still flowing. Toward the end of the radiation period the milliamperage had risen to 5.5 while the voltage had dropped to 28, indicating a lessened resistance. Both current and radiation were then discontinued. The target of the Coolidge tube was scattered midway between the ears. Target-skin distance was 8 inches: 1,500 r units were given at 100 kv.p. unfiltered.

16 days post-radiation there was marked epilation and marked erythema at the base of the right ear. The left ear appeared normal.

24 days—right ear was red near the body. There were scattered scaly patches and there was marked epilation. A slight epilation was noted on the control ear.

35 days—right ear felt cold. There was venous thrombosis. Left ear was normal to touch.

This experiment was repeated using the negative pole on the right ear instead of the positive. The experiments were repeated to a total of six, using the negative pole three times and the positive pole three times. In one instance in which the positive pole was used no difference could be detected between the two ears.

Interpretation of Results.—In normal rabbit tissue the negative pole consistently showed a greater reaction than that of the control area, indicating a definite sensitization. The control area does not merge histologically in an abrupt manner with that of the area under the electrode. We constantly found a peripheral zone where the sensitization was definite but less intense than in the area immediately under the electrode. The positive pole, however, showed inconstant results; if anything, the reaction was slightly diminished. Greater sensitization was obtained when the ionization and irradiation were simultaneously applied. Provided the time interval was the same, no appreciable difference was noted between the pre- and post-radiation and application of the electrode. The experiments with the rabbit ear are interesting and suggestive, and indicate that the sensitization may possibly not depend entirely on the local polar effects.

Fig. 4. Possible effect of current flux. Note marked epilation at the base of right ear. There is only slight epilation on the left. An area including the medial halves of the ears was irradiated at one sitting, while the negative electrode was placed at the tip of the right ear and a current passed through. Note the roughly triangular area of epilation which corresponds with an increase of current flux per unit tissue area.

CONCLUSIONS

The direct electric current can produce sensitization to x-radiation in normal rabbit tissue, producing a local, intense reaction which gradually fades beyond the limit of the electrode. The use of this agent to intensify the effect of external radiation in the treatment of malignant disease has at least a logical as well as an experimental background.

REFERENCE

CARTY, JOHN RUSSELL: The Modification of the Biological Reaction of Living Tissue to X-radiation by Physical and Chemical Agents. RADIOLOGY, **15**, 353, September, 1930.

THE ROENTGENOGRAPHIC DEMONSTRATION OF THE PULMONARY VEINS

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ROENTGENOGRAPHIC demonstration of the pulmonary veins has received less attention than the pulmonary arteries because their anatomical distribution and comparatively delicate structure render them inconspicuous as compared to the more dense neighboring structures on routine teleoroentgenograms.

In order to study the position of the left auricle and pulmonary veins more adequately, postmortem roentgenograms were made of the chest after injection of a suspension of barium sulphate in water. The left auricular appendage was entered after resection of the left fourth, fifth, and sixth costal cartilages, and a catheter was fixed *in situ*. The heart then was allowed to fall back into its resting position, and the chest was closed. The amount of barium injected and the pressure used were controlled by fluoroscopic observation of the injection. Films were taken with the cadaver in the prone position at a four-foot target-film distance. Roentgenographic studies also were made of injections into the right auricle, ventricle, and pulmonary arterial bed through the superior vena cava, and of injections into the arterial and venous system of the lungs.

The studies were controlled further by examination of the contents of the pulmonary arteries or veins after the roentgenograms had been developed to determine whether barium had entered the arteries after a venous injection or *vice versa*.

The findings derived from the films compared favorably with those published by Cottenot, de Balsac, and their collaborators (1), who observed more elaborate precautions to simulate conditions existent during life. Their injections were made through the great vessels in the neck, and films were taken in the erect position at a six-meter target-film distance after reinflation of the lungs.

The pulmonary veins were seen parallel with the arteries in the distal two-thirds of the lung-fields on the injection roentgenograms. At the junction of the middle and inner thirds of the pulmonary beds the veins and arteries separated, the former proceeding to the lateral borders of the left auricle, the latter to the main trunks of the pulmonary arteries. The pulmonary veins united to form two or three main trunks which penetrated the pericardium and entered the posterolateral aspects of the left auricle. Occasionally the main trunks united within the pericardial sac and entered the left auricle as a single lumen. No venous valves were present.

The length of the main venous trunks in the paracardiac region was variable. As a rule the trunks were not more than two or three centimeters long, and subdivided into their secondary branches more abruptly than the pulmonary arteries. At no place in the parenchyma did the larger pulmonary veins approximate the size and thickness of the larger pulmonary arteries.

In general, postmortem injection experiments are open to the criticism that conditions found at autopsy differ from anatomical relationships present during life. Therefore, a final statement concerning the location of the left auricle and pulmonary veins could not be made until they had been visualized in the living individual. It remained necessary to demonstrate the location of the pulmonary veins as they entered the left auricle in patients with normal and abnormal hearts, and compare the findings with the injected preparations.

This was made possible by the planigraphic devices described by Twining (2)

and Alexander (3). By simultaneously moving the film carriage and x-ray tube stand proportionally in opposite directions a single plane parallel to the film within an object such as the chest may be visualized.

Twining's device utilizes an eccentric lever of the first class whose ends are attached to the tube stand and Bucky carriage, respectively. The fulcrum of the lever is movable so that the ratio of movement between the tube and film can be varied. Alexander's device employs a system of pulleys moving the Bucky carriage and tube stand in opposite directions.

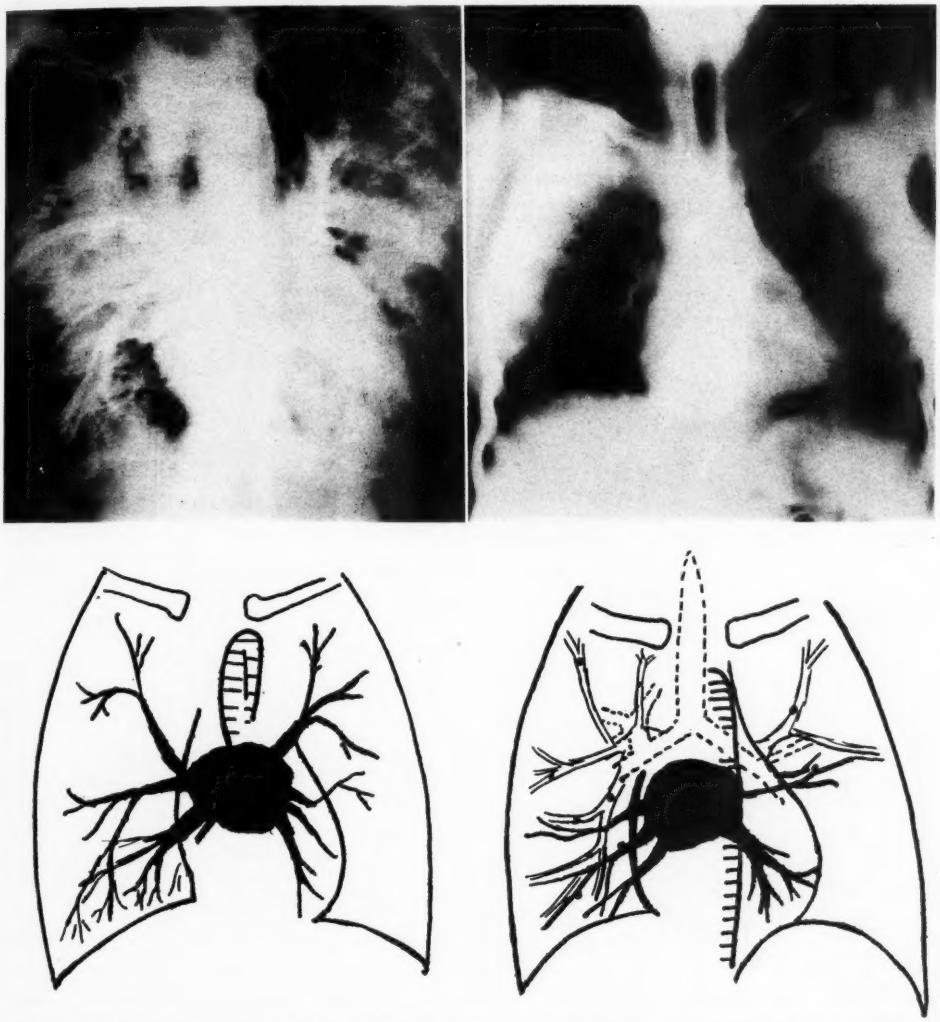

Fig. 1-*A* (*left*). Postmortem injection of the left auricle and pulmonary veins (heavy black lines in sketch) in a 26-year-old woman who died because of a brain tumor. Some barium has entered the ascending aorta (barred lines in sketch).

Fig. 1-*B* (*right*). Planigraphic film of the chest of a healthy woman of 27 of the same height and weight. The pulmonary veins are seen entering both the right and left borders of the left auricle. The pulmonary arterial tree (parallel lines in sketch) is seen also. The black dots in the sketch represent vascular branches cut transversely. The technic of over-penetration was used for this film.

The ratio of movement between the tube and film can be altered by changing the number of pulleys in the system.

visualized clearly. The technic of overpenetration (4) was employed to show the veins behind the cardiac density. By

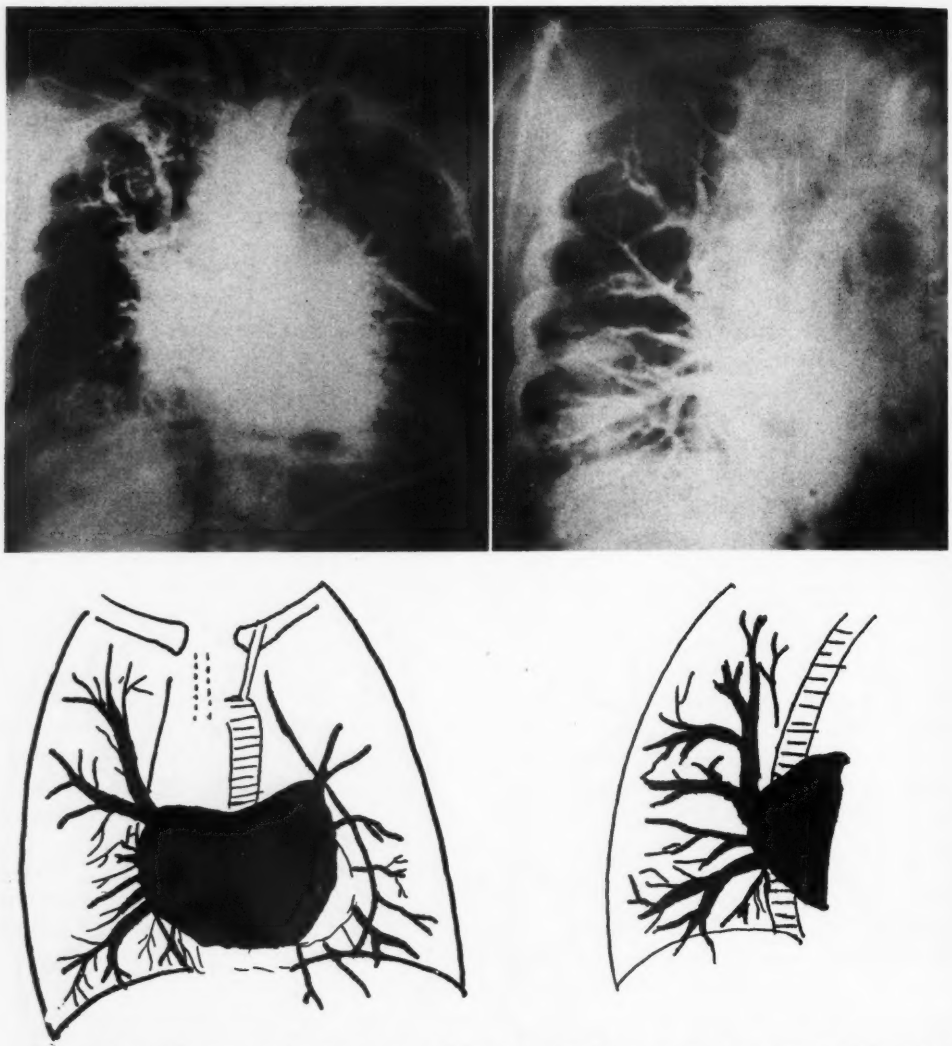

Fig. 2-*A* (*left*). Postmortem injection of the left auricle and pulmonary veins in a 30-year-old man who died of congestive heart failure in the course of rheumatic heart disease. Some barium has entered the aorta, and part of the descending thoracic aorta is seen.

Fig. 2-*B* (*right*). The same preparation roentgenographed in the right anterior oblique projection. The main venous trunks are demonstrated more satisfactorily.

This technic eliminated overlying rib and vascular shadows in the paracardiac regions in planigraphic studies of living individuals. On planigrams made in the proper plane the pulmonary veins were

visualizing the right and left pulmonary veins the lateral borders of the left auricle were demonstrated. The arterial tree in that particular horizontal layer of the chest also was brought into view, and the veins

and arteries could be traced to their main branches.

Planigraphic films of the chest of two living individuals were chosen for comparison with two postmortem injection studies of the left auricle and pulmonary veins. One was a patient with a normal heart, the other a patient with rheumatic heart disease. Care was taken to see that the pairs of individuals studied were comparable from the point of view of age, height, weight, and cardiac status.

The pulmonary veins in the normal living person were demonstrated ascending to the upper portion of the heart shadow, entering an area of increased density similar in size, shape, and position to the left auricle and the postmortem preparation roentgenogram. An over-penetrated roentgenogram made at the same intrathoracic level showed the pulmonary veins well within the cardiac contour entering the left border of the left auricle. The arterial tree and the meeting points of the veins and arteries could be seen clearly. The position of the left auricle was approximately the same in the prone and erect positions. This may be due to the relative fixation afforded the posterior aspect of the left auricle by the pulmonary veins.

The clinical diagnosis of the patient with rheumatic heart disease was mitral stenosis and insufficiency, and aortic insufficiency. Fluoroscopic examination of his heart revealed left auricular enlargement posteriorly, superiorly, and to the right graded three plus, left ventricular enlargement posteriorly graded two plus, right ventricular enlargement involving the outflow tract graded three plus and inflow tract graded two plus, and right auricular enlargement graded two plus. No valvular calcifications could be demonstrated. His cardiac condition corresponded with that found at autopsy in the patient upon whom the injection experiment had been performed.

The location of the left auricle was the same in both sets of films. The pulmonary veins were located four inches from the anterior chest wall. The chest measurement from sternum to spine measured with a caliper at the sixth dorsal vertebra was seven inches. Planigraphic study at a three-inch distance from the anterior chest wall showed the right border of the left auricle half an inch within the right cardiac border.

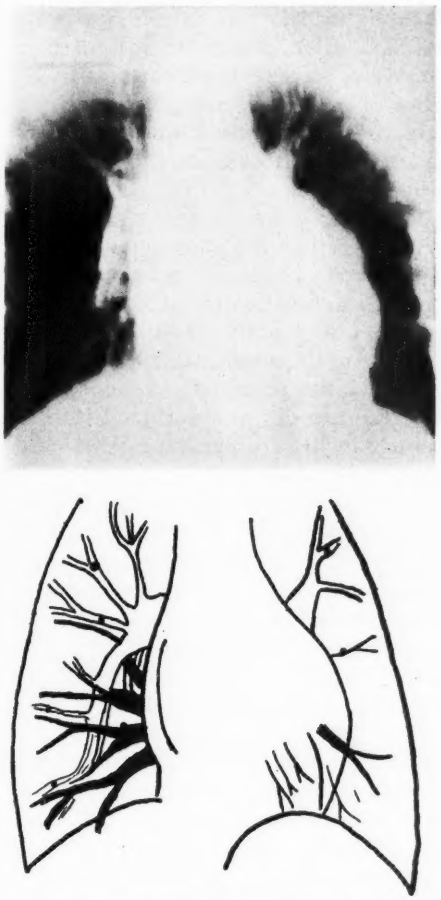

Fig. 2-*C*. Planigraphic film of the chest of a man 26 years old with a similar rheumatic cardiac condition. The main venous trunks are seen entering the right cardiac border. Some of the pulmonary veins are seen behind the cardiac density. The arterial tree also is visualized.

The pulmonary veins were seen on the planigrams entering the right cardiac border as three large trunks arranged in radial fashion about a centimeter apart. The left pulmonary veins were not visualized as well because of the cardiac density; several branches, however, could be seen.

On the postmortem injection films the size and distribution of the right pulmonary veins were seen better in the right anterior oblique projection than in the postero-anterior projection, and corresponded in size and distribution to those seen in the living patient.

The arterial tree in that plane could be seen in detail on the planigram. The veins and arteries began to course in parallel direction approximately at the junction of the inner and middle thirds of the lung fields. In the mesial third of the right lung field the pulmonary veins separated from the arteries and gathered into large main branches to enter the right cardiac border as described.

After these studies were made, a number of roentgenographic studies of the heart made in the postero-anterior, right anterior oblique, and left anterior oblique projections were re-examined. In many of these the pulmonary veins could be seen faintly but definitely. On the oblique films, especially those made in the left anterior oblique projection, shadows of increased density could be demonstrated below the left main bronchus. Comparison of these shadows with roentgenograms of the injected preparations made in similar positions indicated the strong possibility that the infra-bronchial shadows were cast by the pulmonary veins.

SUMMARY

Roentgenographic studies were made of injections of the left auricle and pulmonary veins with the organs *in situ* in a cadaver with a normal heart and a second cadaver with rheumatic heart disease. These were compared with planigraphic studies of the chest of two living persons with similar cardiac conditions. The cases were chosen so that the films were comparable.

The location of the pulmonary veins and left auricle in the postmortem preparations corresponded with that of the living individuals.

The pulmonary veins and arteries can be studied more advantageously in planigraphic x-ray examinations of the chest than in ordinary roentgenograms. It now should be possible to study the condition of the pulmonary veins more thoroughly.

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REFERENCES

(1) COTTENOT, P., and HEIM DE BALSAC, R.: Étude Expérimentale de la Semiologie Radiologique de l'Appareil Circulatoire au Moyen de la Cardio-vasographie Postmortem. Acta Radiol., **17,** 256–274, 1936.

(2) TWINING, E. W.: Tomography, by Means of Simple Attachment to Potter-Bucky Couch. British Jour. Radiol., **10,** 332–347, April, 1937.

(3) ALEXANDER, G.: A Simple and Inexpensive Tomographic Method. Am. Jour. Roentgenol. and Rad. Ther., **39,** 956, 1938.

(4) EPSTEIN, BERNARD S.: The Technic of Radiographic Over-penetration as Applied to Radiology of the Aorta. Am. Jour. Roentgenol. and Rad. Ther. In press.

EMPHYSEMATOUS CHOLECYSTITIS AND PERICHOLECYSTITIS[1]

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FOR many years it has been an axiom accepted by the majority of roentgenologists that, without the aid of a contrast medium, the normal gall bladder cannot be definitely visualized in the roentgenogram. Any visualization in the flat plate is, therefore, attributed to pathologic factors: thickening of the gall-bladder wall in certain forms of cholecystitis; calcifications in the wall in "porcelain gall bladder"; calculi in cholelithiasis; inspissation of bile or sedimentation of amorphous calcium carbonate in the so-called "calcium milk bile" (*Kalkmilchgalle*) and similar factors.

In my search of the radiological literature I have failed to find any references to the visualization of the gall bladder by spontaneous gas-filling as it is encountered in gaseous or emphysematous cholecystitis. This omission appears the more unusual when we consider that not only is the presence of gas-forming bacteria in the biliary system a common occurrence, but also that this condition has been described often both by surgeons and pathologists.

The first references to emphysematous cholecystitis date back to the beginning of the present century. In 1901, Stolz (1) reported three cases in which, at autopsy, gas was discovered in the gall bladder. In 1925, Kirchmayr (2) described a case of emphysematous cholecystitis diagnosed during cholecystectomy. Two years later, Wahlberg (3) published four cases of gas bacillus infection observed in 1,000 gall-bladder operations. This material included two cases previously reported by Brütt (4). While, however, Brütt had been able to recognize gaseous cholecystitis during operation, Wahlberg's diagnoses were based exclusively on post-operative bacteriologic findings.

It lies beyond the scope of this paper to enter the discussion concerning the rather complicated and by no means undisputed problem of the bacteriology of gall-bladder disease. Suffice it to say that the percentage of positive bacterial findings in gall-bladder disease is high, though it varies within wide limits in different reports. A recent review of 2,162 cases of cholecystitis studied bacteriologically after cholecystectomy and published by Rehfuss and Nelson (5), sets the average figure for positive bacterial cultures from the gall-bladder wall at more than 45 per cent and the positive cultures from the gall-bladder contents (bile) at about 30 per cent.

I shall confine myself to a brief résumé of the bacteriologic findings as far as they apply to emphysematous cholecystitis.

In all cases reported by Stolz, *B. coli communis*, *B. lactis aerogenes*, and various aerobic sporulating bacilli were recovered. In one case, a non-pathogenic diphtheroid and *Staphylococcus pyogenes aureus* were also found. However, cultures for obligate anaerobes were negative. In Brütt's and Kirchmayr's cases, Fränkel's gas bacillus was isolated and was considered the cause of the emphysematous bile changes. The same observations were made and similar conclusions were reached in Wahlberg's cases. In several cases mentioned in the literature the identification of the bacteria meets with considerable difficulty, partly due to the lack of definite description and partly to widely varying classification and nomenclature. Fränkel's gas bacillus is, for example, identical with *B. welchii*, which latter term is used with preference in America, but the correct and bacteriologically approved term for this organism is now *B. perfringens*. It is no rarity that the same bacillus is described under three or four different names by different authors, which fact, of course, is rather confusing

[1] Presented before the Fifth International Congress of Radiology, at Chicago, Sept. 13–17, 1937.

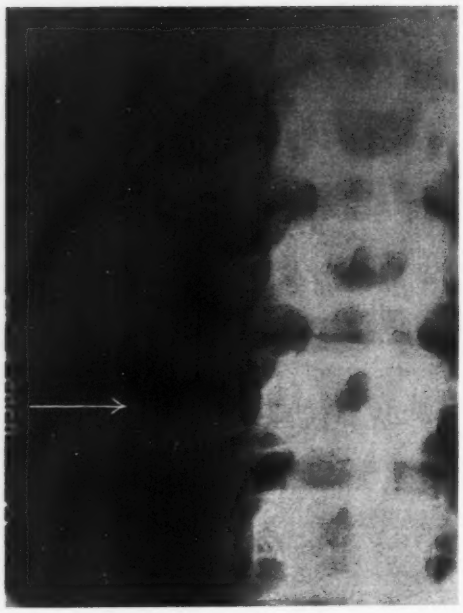

Fig. 1. Gas-filled gall bladder before cholecystography (Case 1).

for both bacteriologists and non-bacteriologists. Of gas-forming bacteria, *B. coli communis* is most frequently encountered in the gall bladder (in 11 to 16 per cent of the cases, according to Andrews and Henry), next *B. perfringens* (in 9 to 11 per cent of the cases, 6).

The first of our cases, J. C., a miner, 37 years of age, was admitted to the Colorado General Hospital on account of periodically recurring pains in the right upper abdominal quadrant combined with intermittent attacks of fever. These attacks had been observed for approximately three years and had been clinically diagnosed as due to cholecystitis. Outside of marked tenderness in the gall-bladder region the clinical examination was essentially negative. Gastric analysis showed low acidity (free HCl 16; total acidity 28). The blood examination yielded normal figures for hemoglobin, erythrocytes, and leukocytes, but a high polymorphonuclear percentage (85 per cent) and a low lymphocyte count (about 9 per cent). Examinations for malaria parasites and tubercle bacilli, as well as Wassermann reaction, were negative. The evening temperatures rose to about 103° F., the pulse rates to 118. There was no evidence of jaundice.

The x-ray examination before cholecystography revealed an elongated gas-filled area in the right hypochondrium corresponding in location to the point of maximum tenderness and suggesting in shape and outlines a slender gas-filled gall bladder (Fig. 1).

Cholecystography showed this identical area definitely, though faintly, filled with gall-bladder dye (Fig. 2).

Further examinations after barium meal and enema definitely excluded gas accumulations in the gastro-intestinal tract, especially in duodenum and colon, as sources of the reported shadow.

The final x-ray diagnosis was: Gas filling of poorly functioning gall bladder, apparently due to emphysematous cholecystitis.

Under a dietary régime and bed rest the patient improved rapidly so that surgical intervention was deemed unnecessary. At the time of this report he is without symptoms and feeling well.

The second case, confirmed by operation and necropsy, has already been published in the surgical literature (7) by the surgeon, Dr. C. F. Hegner, Professor of Surgery of the University of Colorado School of Medicine, and I am greatly indebted to Dr. Hegner for his permission to use his data in the case.

This case was observed in a farmer, J. L., 62 years of age, who complained of recurring attacks of pain in the right hypochondrium. These attacks had, at the time of admission to the Colorado General Hospital, lasted for about five days and were accompanied by the vomiting of bile-colored fluid. Jaundice had developed two days after onset of symptoms and was, at admission, marked in both skin and sclera. The right upper abdominal quadrant was slightly rigid and decidedly tender. The patient did not appear acutely ill although his temperature occasionally reached 102° F. The blood count showed:

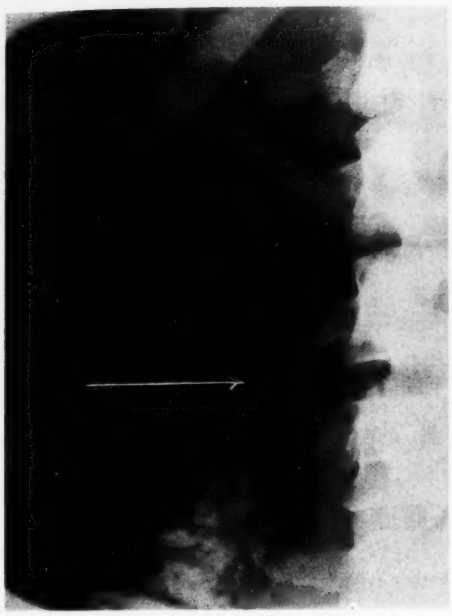

Fig. 2. Visualization of gall bladder after cholecystography (Case 1).

Fig. 3. Gas-filled gall bladder with gas streaks in pericholecystic area (Case 2).

erythrocytes 4,910,000; leukocytes 14,100 of which 90 per cent were polymorphonuclears and 10 per cent lymphocytes. Pulse rate was 92; blood pressure 136/76. Wassermann reaction was negative.

The x-ray examination of the gall bladder (intravenous cholecystography) showed a large pear-shaped, well-circumscribed area of gas accumulation in the right hypochondrium. In location, size, and contours this area suggested a large gas-filled gall bladder and the diagnosis of emphysematous cholecystitis was given. A series of concentric gas streaks in the surrounding tissue seemed to point to pericholecystic extension of the emphysema (Fig. 3).

A later x-ray examination of the gastrointestinal tract showed a constant deformity of the duodenal bulb, apparently due to extrinsic (gall-bladder) pressure.

This area was tender on pressure and tympanitic on percussion.

Exploratory laparotomy was performed one week after admission. Colon, omentum, duodenum, and stomach were found to be intimately adherent to the margin of the liver and the region of the gall bladder. A soft friable mass was felt in this area into which a needle of a 20 c.c. syringe was introduced. The syringe immediately filled up with gas under pressure sufficient to push the plunger out of the barrel. This procedure was repeated several times. The outlines of the gall bladder were rather indistinct. No biliary calculi were palpated and it was considered advisable only to drain the gall bladder. A rubber tube was inserted into the supposed gall-bladder cavity. The patient left the operating table in good condition. A post-operative rise in temperature was successfully combated by the injection of Cutter's triple anaerobic serum. The composition of this serum is similar to that which was used by the French against gas gangrene in the World War. The patient seemed well on the way to an uneventful recovery, when, suddenly, on the fourth post-operative day, he died of pulmonary embolism.

The autopsy findings (Dr. W. C. Johnson) are summarized in the following anatomical diagnoses: "Suppurative chole-

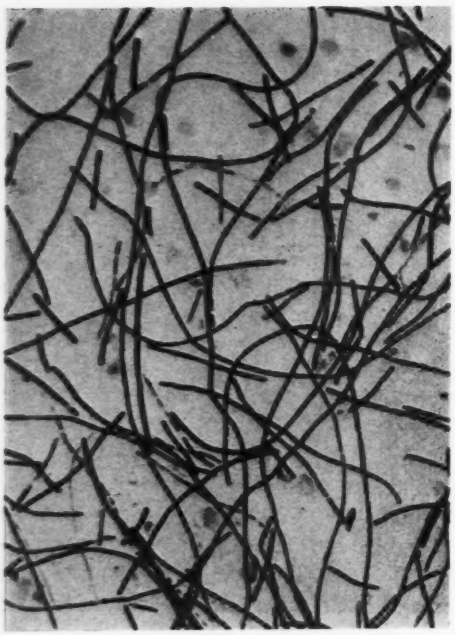

Fig. 4. Microscopic slide preparation from anaerobic blood agar slant demonstrating microorganism found in Case 2. Gram stain; magnification, 1,200 times.

cystitis and pericholecystitis, cholelithiasis, necrosis with perforation of the neck of the gall bladder, slight biliary cirrhosis of the liver, chronic inflammation and fibrosis of the liver adjacent to the gall bladder, thrombosis of the external and internal iliac veins, and pulmonary embolism, the latter being considered the cause of death."

The microscopic examination of the gall bladder showed loss of nuclear stain; the coat of the gall bladder was thickened and studded with yellow bile pigment. Sections of the wall showed few long filamentous Gram-negative organisms. No condition comparable to "foam liver" (*Schaumleber*), as described by some authors in gas bacillus infections, was noted.

The bacteriological examination was done by Dr. I. C. Hall and extended to specimens both antemortem and postmortem.

A specimen of bloody material taken from the gall-bladder area during the operation showed microscopically a few polymorphonuclear leukocytes but no bacteria. However, a gas-forming bacillus somewhat resembling *B. perfringens* was recovered in the cultures (Fig. 4). The same organism was found in a second specimen also taken from the supposed gall-bladder cavity. This organism resembled *B. perfringens* in its physiology but was somewhat atypical in morphology. The cultures were tested for pathogenicity in a guinea-pig and found to produce moderate edema with some emphysema. In a control pig the edema was prevented by 1 c.c. of Cutter's triple anaerobic serum.

A blood culture taken about three hours after operation was negative.

The heart blood taken postmortem proved sterile.

The extravasated bile, dark green and thick, from the site of operation showed microscopically numerous pus cells and Gram-positive filaments and rods resembling those isolated at the operation, but, owing to an invasion by various intestinal bacteria, it was impossible again to isolate the organism found during the operation.

A few words may not be amiss concerning the possible routes of bacterial invasion in gall-bladder disease, especially in emphysematous cholecystitis.

Theoretically these routes may be: (1) the blood or lymph streams; (2) direct extension from neighboring organs or from adhesions; (3) the bile passages either descending from the liver or ascending from the duodenum.

While Gilbert and Lippman (8), in 1902, still considered the ascending infection from the duodenum the route *par excellence*, later investigators have laid increasing emphasis on the other possibilities, *i.e.*, blood and lymph circulation or direct extension. Certain conclusions may possibly be drawn from the type of bacteria encountered. According to Rehfuss and Nelson, the bacterial flora of the diseased gall bladder may be roughly divided into a "head group" and a "bowel group." To the first group belong bacteria which are usually found in foci of the head, *e.g.*, in

pyorrhea, tooth infections, tonsillitis, sinus disease, etc., in other words, primarily bacteria of the *Streptococcus viridans* family. The second group comprises micro-organisms habitually found in the gastro-intestinal tract, *i.e.*, the colon-typhoid group and gas-producing bacteria. While, nowadays, most authors seem to be agreed on the predominance of blood-borne infection in gall-bladder disease, thus giving preference to the bacteria of the "head group," the other routes of invasion must not be overlooked. The observation of barium in the gall bladder after oral barium administration and the experiments of Bond (9), who was able to demonstrate the presence of charcoal in the gall bladder after rectal administration, show the importance of ascending infection from the duodenum, probably in cases of impairment of the sphincter of Oddi.

The question of relative significance of gall-bladder wall to gall-bladder contents for the localization and isolation of bacteria, as well as the relative rôle of the different bacteria in the causation of cholecystitis, have led to lively polemics and are still far from being solved.

In our cases, too, any opinion concerning the way of infection can be only speculative.

In neither case, definite foci of infection outside the gall-bladder area could be established. In Case 1 the gas accumulation was confined to the gall bladder proper. In Case 2 the sequence of roentgenograms seemed to prove that the initial infection and gas accumulation developed in the gall bladder and only secondarily extended to the pericholecystic region.

No definite observations or facts can be adduced to prove or disprove an ascending infection from the duodenum. However, in my opinion, this should be considered the route of choice in emphysematous cholecystitis, not only because the gas-forming bacteria belong to the above-mentioned "bowel group" but also because, specifically in our cases, the negative blood cultures and the absence of gas bacillus infection in other parts of the body militate against the conception of blood-borne bacterial invasion.

To what extent the apparently favorable influence of the anaerobic serum and the striking lymphopenia in both cases may be utilized for diagnostic conclusions is open to discussion.

On account of the limited number of cases, it cannot be my intention to present a definite and well-rounded pathological entity at the present time. The only purpose of this paper is to call the attention of the radiological profession to a picture which so far has escaped mention in our literature but which apparently well deserves to be added to the roentgenological criteria of gall-bladder disease.

REFERENCES

(1) Stolz, A.: Ueber Gasbildung in den Gallenwegen. Virchow's Archiv f. path. Anat., **165,** 90, 1901.

(2) Kirchmayr, L.: Ueber einen Fall von Gasbrand der Gallenblase. Zentralbl. f. Chir., **52,** 1522, 1925.

(3) Wahlberg, K.: Die Gasbazilleninfektion der Gallenblase. München. med. Wchnschr., **74,** 2095, 1927.

(4) Brütt, H.: Gasbazilleninfektion des Pankreas und Pankreasnekrose. Virchow's Archiv f. path. Anat., **246,** 33, 1923.

(5) Rehfuss, M. E., and Nelson, G. M.: The Problem of Infection in Gall-bladder Disease, with a Report on the Experimental Production of Cholecystitis. Am. Jour. Digestive Diseases and Nutrition, **1,** 759, 1935.

(6) Andrews, E., and Henry, L. D.: Bacteriology of Normal and Diseased Gall Bladders. Arch. Int. Med., **56,** 1171, 1935.

(7) Hegner, C. F.: Gaseous Pericholecystitis with Cholecystitis and Cholelithiasis. Arch. Surg., **22,** 993, 1931.

(8) Gilbert, A., and Lippman, A.: Bacteriologie des cholecystites. Comptes rend. Soc. de biol., **54,** 1189, 1902.

(9) Bond, C. J.: An Address on Ascending Currents in Mucous Canals and Gland Ducts and Their Influence on Infection. British Med. Jour., **2,** 232, 1905.

EFFECTS OF ROENTGEN RAYS ON THE ACTIVATION AND PRODUCTION OF THE ENZYME TYROSINASE IN THE INSECT EGG (*ORTHOPTERA*)[1, 2]

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INTRODUCTION

MOST investigations on radiant energy in relation to enzymes indicate that enzymes are affected by various types of radiations. Sunlight and ultraviolet radiation have been used extensively and result, for the most part, in varying degrees of inactivation with an occasional report of stimulation (Duggar, 8). The situation in regard to the effects of roentgen rays is similar. Inactivation, more or less resembling the effects of heat, is often reported (Clark and Northrop, 7). In a few instances, acceleration has been obtained by short exposures, with inactivation only after extensive x-irradiation (Richards, 15). The action of radium rays on digestive enzymes has been investigated and found to result in destruction of their activity (Henri and Mayer, 10).

Experimental studies on the effects of visible and ultra-violet rays on the enzyme, tyrosinase, demonstrate that it also is altered by irradiation. In two instances it has been reported that the activity of this enzyme was greatly reduced by exposure to ultra-violet rays (Pincussen and Hammerich, 13; Agulhon, 1). It has also been shown (Agulhon, 2; Przibram and Dembowski, 14) that visible light destroys tyrosinase only in the presence of oxygen, and it is suggested (Przibram and Dembowski, 14) that the destruction may be due to the formation of hydrogen peroxide, inasmuch as ultra-violet rays do not destroy the enzyme's activity when it is dissolved in glycerin. In more recent investigations (Narayanamurti and Ayyar, 11; 12) the slightly increased activity after ultra-violet irradiation is explained as being due to a decrease in the negative charge of the enzyme permitting increased adsorption catalysis. It has also been shown (Willcock, 17) that tyrosinase is an exception to the rule in that it is not affected by exposure to beta and gamma rays of radium. In view of these considerations it was thought that the effects of roentgen radiations on tyrosinase might be of interest, and it is the purpose of the present paper to present results of a study on the effects of roentgen rays on the activity of the enzyme and on its production in the developing orthopteran egg.

MATERIAL AND METHODS

Several features that make the eggs of the grasshopper, *Melanoplus differentialis*, desirable for use in an investigation of this kind have previously been pointed out (Bodine, 3). The effects of roentgen irradiation on both tyrosinase solutions and eggs were determined. Eggs of varying ages throughout both developmental periods (pre-diapause and post-diapause of 18 days each) as well as during the intervening inactive period (three to four months at 0° C.) were irradiated.

The preparation of the enzyme solution was similar to that of Bodine, Allen, and Boell, (5). Briefly, it was as follows: 60 to 200 eggs were washed in tap water; sterilized in 70 per cent alcohol for ten minutes; washed three times in sterile, distilled water; washed twice in buffered NaCl solution (50 c.c. 0.9 per cent NaCl; 25 c.c. M/15 Na_2HPO_4; 25 c.c. M/15 KH_2PO_4) of *p*H 6.8; transferred to a sterile

[1] Aided by a grant from the Committee on Radiation of the National Research Council and by the Rockefeller Foundation Fund for Research on the Physiology of the Cell.

[2] The author wishes to express his appreciation to Professor J. H. Bodine for the manifest interest and many helpful suggestions rendered during the progress of this investigation.

[3] Unpublished observations of Dr. E. E. Carothers.

glass mortar and thoroughly ground. The mixture was poured into a sterile graduated centrifuge tube with rinsings of the mortar with buffered NaCl to bring the total to a concentration of 20 eggs per c.c., not including the shells of the eggs (approx. 0.5 c.c.). Centrifuging for five minutes at 1,060 r.p.m. separated this brei into three layers previously designated (Bodine, Allen, and Boell, 5) as *A*, *B*, and *C*. *A* was a thin lipoidal, surface layer. *B* constituted the major portion containing almost all of the tyrosinase. *C*, approximately 0.5 c.c., was at the bottom and included the egg shells, etc. Layer *A* was pipetted off and layer *B* was used for the determination of tyrosinase activity of irradiated eggs. For the irradiation of tyrosinase in solution the proteins were precipitated from layer *B*, leaving a supernatant fluid designated as B_1 (Bodine, Allen, and Boell, 6). This solution retained its activity for several weeks when kept at 0° C.

Tyramine-HCl was used as substrate in such concentration that 388 c.mm. of oxygen are utilized by the tyrosinase in complete oxidation of 0.3 c.c. of the solution (Bodine and Boell, 4). The supply of the substrate was kept at 0° C. to prevent autoxidation.

An investigation of the activation of tyrosinase from the orthopteran egg has been conducted (Bodine and Allen, 6) and it has been demonstrated that there is an activating substance occurring naturally in the egg. It was further discovered that in centrifugation of egg brei the natural activator was segrated in the top layer (*A*) and could be removed with a pipette. This left an extremely inactive preparation of tyrosinase (layer *B*), as indicated by the negligible amount of oxygen uptake when the substrate was added. Of many compounds tried in a search for artificial activators it was found that sodium oleate, at a final concentration of from 0.05 to 0.1 per cent, gave the maximum and most immediate activation of the enzyme. For this reason it was used as activator in this investigation.

It is to be noted that there are both active and inactive forms of tyrosinase on which to determine the effects of roentgen rays. Omission of the activator (0.1 c.c. 2 per cent sodium oleate) from the manometer flask permits ready detection of any activation due to roentgen irradiation, while the activated enzyme should show any inhibition or destruction of activity resulting from roentgen rays.

Determinations of enzyme activity were carried out in standard Warburg manometers at 25° C. In a typical experiment the various reagents were arranged as follows: 1 c.c. of *B* or B_1 (containing tyrosinase from 20 eggs); 0.1 c.c. of 2 per cent sodium oleate; 0.1 c.c. of 10 per cent potassium hydroxide (center well); 1.6 c.c. of buffered (p_H 6.8) 0.9 per cent sodium chloride; 0.3 c.c. of 0.4 per cent tyramine HCl (in the side bulb). A manometer flask containing no tyrosinase served as a thermobarometer. In preliminary experiments it was determined that no detectable autoxidation of the substrate occurred. The activity of the tyrosinase was thus determined from the rate of oxygen uptake.

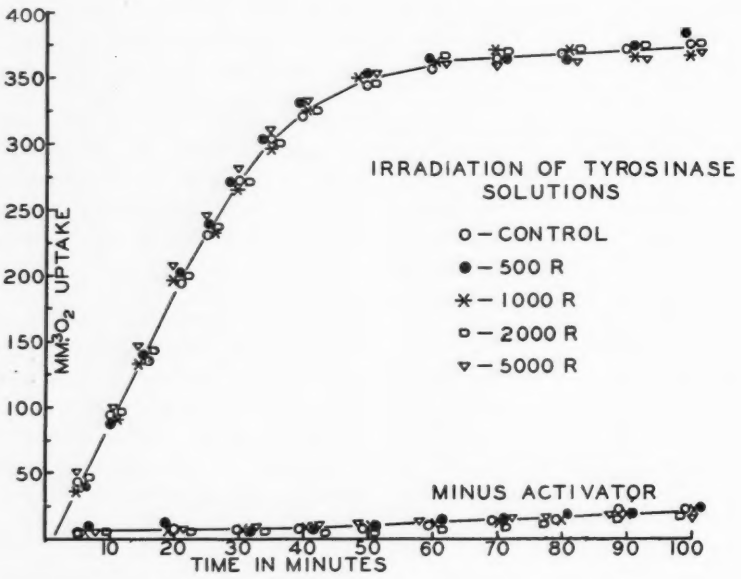
The roentgen apparatus used was a double cross arm mechanically rectified unit energizing a Coolidge broad focus universal air-cooled tube at 130 kv.p. and 5 ma. The eggs were irradiated on several layers of moist filter paper in a petri dish and, for doses of 10,000 r or less, were given 200 r per minute at 25 cm. distance. For greater doses the distance was 15 cm. and the reception was 554 r per minute. The intensity was measured by means of a commercial dosimeter filtered through 2 mm. of cardboard. Doses of 100,000 r or more were given in two exposures not more than 24 hours apart. Tyrosinase extracts were also irradiated in petri dishes. In no instance did the temperature of the material exceed 27° C. during irradiation.

RESULTS

1. *Effects of Roentgen Rays on the Activity of Tyrosinase Solutions.*—The tyrosinase solution used in these experiments was that previously described as B_1. It was entirely satisfactory in that it suffered no

apparent physical change after rather prolonged irradiation. Attempts to use the *B* fraction were unsuccessful, due to the precipitation of proteins during irradiation making it difficult to pipette.

It should be explained that the time in-



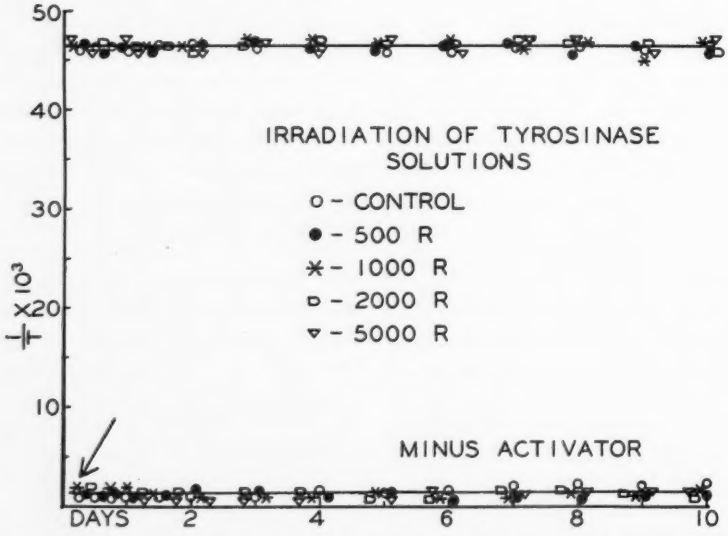


Fig. 1 (*above*). The effects of roentgen radiation of tyrosinase solutions prepared from the eggs of the grasshopper, *M. differentialis*. The first part of the upper curve represents the activity of the activated enzyme. Ordinate, mm.³ total oxygen uptake; abscissa, time in minutes from the addition of the substrate.

Fig. 2 (*below*). Effects of roentgen radiation of tyrosinase solutions prepared from grasshopper eggs. Upper curve represents activated enzyme. Arrow indicates point of irradiation; ordinate, reciprocal of time for half life; abscissa, days from irradiation.

terval between completion of the irradiation and beginning of manometric measurements was kept at 10 minutes in all cases.

The results of typical series of such experiments are presented in Figure 1. From the upper curve it may be seen that there is no inactivation of the tyrosinase by roentgen rays in the amounts given. During the first 20 minutes the activity is a function of the enzyme, not of the substrate concentration, and the points representing exposures of 500 to 5,000 r are nearly superimposed. If the activity of the enzyme had been partially destroyed, the slopes of the curves representing irradiated tyrosinase would have been lessened.

The lower curve in Figure 1 demonstrates the extreme inactivity of the tyrosinase when the sodium oleate is omitted. This non-activated enzyme shows less than 5 per cent of the oxygen uptake occurring after activation. It is seen then that any activation by the roentgen rays should be apparent through an increased oxygen uptake which, in turn, would increase the slope of the lower, experimental curves.

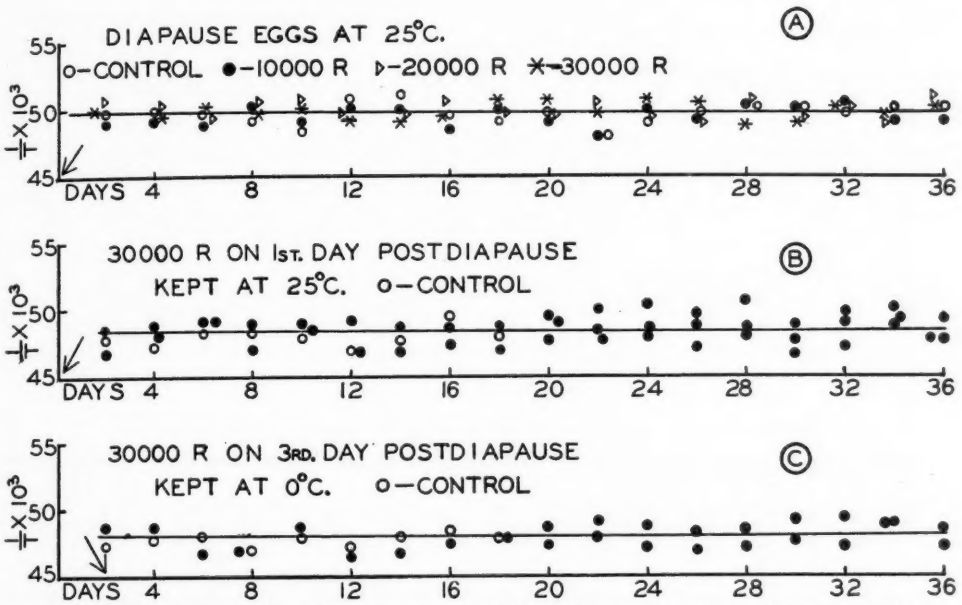


Fig. 3. Effects of roentgen irradiation of the eggs of *M. differentialis* on the activity of the contained tyrosinase. *A* represents enzyme from non-developing eggs; *B*, enzyme from developing eggs, and *C*, tyrosinase from developing eggs kept at low temperature to prevent further development. Curves representing non-activated tyrosinase were omitted to conserve space. Arrows indicate day of irradiation; ordinates, reciprocal of time for half life; abscissæ, days of development at 25° C.

The ordinates of the following graphs were determined as the reciprocal of the time in minutes to utilize half of the theoretical total amount of oxygen multiplied by 10^3.

That tyrosinase solutions (B_1) are not affected by roentgen irradiation up to 10 days after treatment is shown in Figure 2. Doses of from 500 to 5,000 r were given. The activity of the enzyme was determined several times during the first two days and daily thereafter to the tenth day. There was no deviation from the controls in either the activated or the non-activated tyrosinase extracts.

2. *Effects of Roentgen Irradiation of Eggs on the Activity of the Contained Tyrosinase.*

[3] Unpublished observations of Dr. E. E. Carothers.

—In these experiments the activity of tyrosinase in fraction *B* prepared from irradiated and control eggs was determined with and without activation with sodium oleate. Figure 3 shows that roentvated enzyme have been omitted to conserve space but in no case was there any activation of the tyrosinase by the roentgen rays.

3. *Effects of Roentgen Irradiation of the*

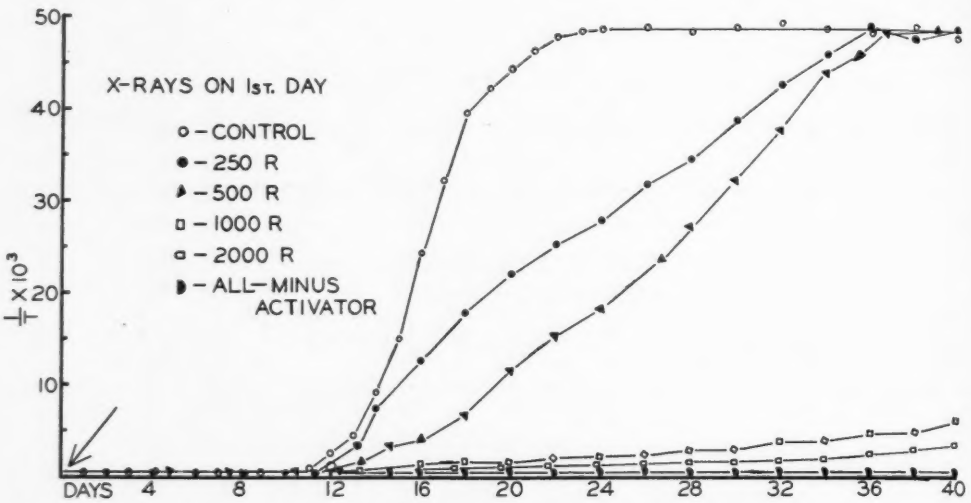


Fig. 4. Effects of roentgen irradiation of day-old eggs on the subsequent tyrosinase formation. Arrow indicates day of irradiation; ordinate, reciprocal of time for half life; abscissa, days of development at 25° C.

gen irradiation of the eggs produces no effect on the activity of the contained tyrosinase. *A* represents the effects of 10,000, 20,000, and 30,000 r on diapause eggs kept at developmental temperatures. The activity of the enzyme remains constant and equal to that of the control group. In *B* is shown the effects of 30,000 r on the tyrosinase of post-diapause eggs kept at 25° C., where they normally would contain rapidly developing embryos. The development of the irradiated embryos ceases in seven to twelve days and none of them ever hatch (controls hatch in 18–20 days) but the level of the tyrosinase activity is maintained equal to that of the controls and there seems to be no effect on the enzyme. A similar experiment is represented in *C* except that after irradiation the eggs were kept at 0° C. to prevent further development of the embryos. The results are also similar in that the tyrosinase activity is unaffected by the roentgen rays. Curves representing non-acti-

Eggs on the Production of Tyrosinase.—Evans (9) showed that comparatively small doses (500 r) of roentgen rays during the first few days after laying completely prevent further development of the embryo, and the question naturally arises as to the effects of such treatment on the production of tyrosinase. The results of exposing day-old eggs to 250, 500, 1,000, and 2,000 *r* are shown in Figure 4. The normal development of the enzyme (control curve) is seen to begin about the twelfth day and to reach completion around the eighteenth day (see Bodine, Allen, and Boell, 5). The smallest of the doses (250 r) reduces the rate of tyrosinase production to such an extent that an additional 15 days is required for the concentration of the enzyme to reach the control level. The effects of 500 r are similar but to a more marked degree: 1,000 and 2,000 r produce an inhibition of tyrosinase formation from which there is little recovery. Even 40 days after irradiation the activated enzyme responds

but slightly. The curve representing non-activated tyrosinase indicates that in no instance was there any activation by the irradiations.

In an effort to detect periods of varying susceptibility to roentgen irradiation several series of eggs were exposed to single doses of 1,000 r on the first to fifth day, inclusive, and one series was given 33,000 r on the second day. The results of this treatment are shown in Figure 5. During the first few days after laying there is a tremendous increase in resistance to roentgen irradiation as regards the subsequent formation of tyrosinase. Whereas 1,000 r on the first day almost completely prevents the production of the enzyme, the same exposure on the second day reduces the rate of formation to about 80 per cent of the control value; the control concentration, however, is finally reached. The effects of 1,000 r decrease with the age of the eggs until the fifth day, when this exposure causes no variation in tyrosinase formation from that of the control eggs: 33,000 r on the second day inhibits the development of the enzyme much less than 1,000 r on the first day. None of the exposures produced any activation of the tyrosinase.

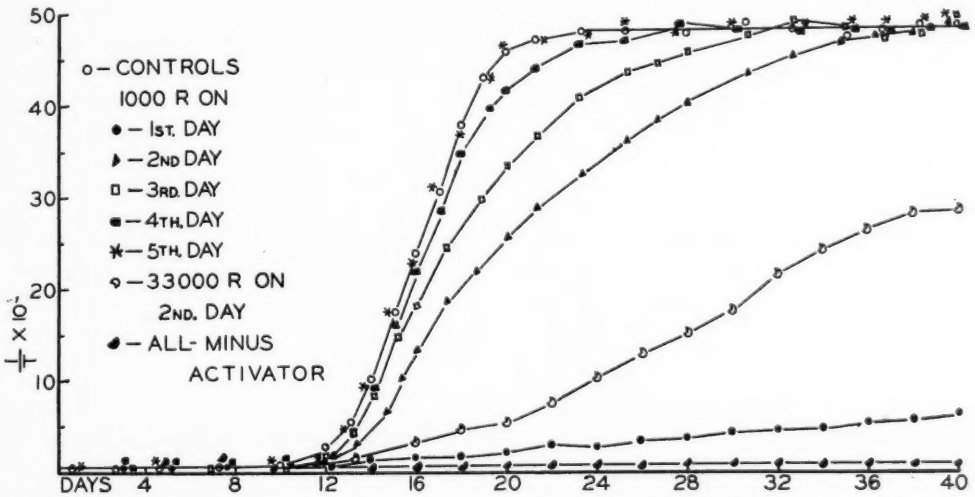


Fig. 5. Showing increasing resistance to roentgen irradiation with age of egg in respect to tyrosinase formation. Ordinate, reciprocal of time for half life; abscissa, days of development at 25° C.

It becomes a question then as to the extent of this increasing resistance to roentgen radiation as the eggs develop. Figure 6 shows the results of experiments with larger doses of roentgen rays on the sixth day of development. It will be noted that of exposures to 5,000, 10,000, 20,000, and 30,000 r only the latter three cause any consistent reduction in the rate of tyrosinase formation as compared to the controls. The degree of effect retains its relative position with respect to the amount of irradiation, but in all cases the effect is slight. The beginning of tyrosinase production is retarded, but when once begun the rate of formation is almost identical with that of the controls. The attainment of maximum concentration is retarded with respect to the controls but little more than the retardation of the beginning of tyrosinase formation.

Intensive treatment with roentgen rays at a time when production of tyrosinase is occurring most rapidly had but little effect upon the rate of its production. The results of such experiments are summarized in Figure 7. It has been shown (Bodine, Allen, and Boell, 5) and confirmed (see control curves) that the tyrosinase is being

produced very rapidly from the fourteenth day to the sixteenth day. For this reason the fifteenth day was chosen for irradiation. r of roentgen rays. Only the two larger doses produced any apparent effect, resulting in nothing more than a slight reduction

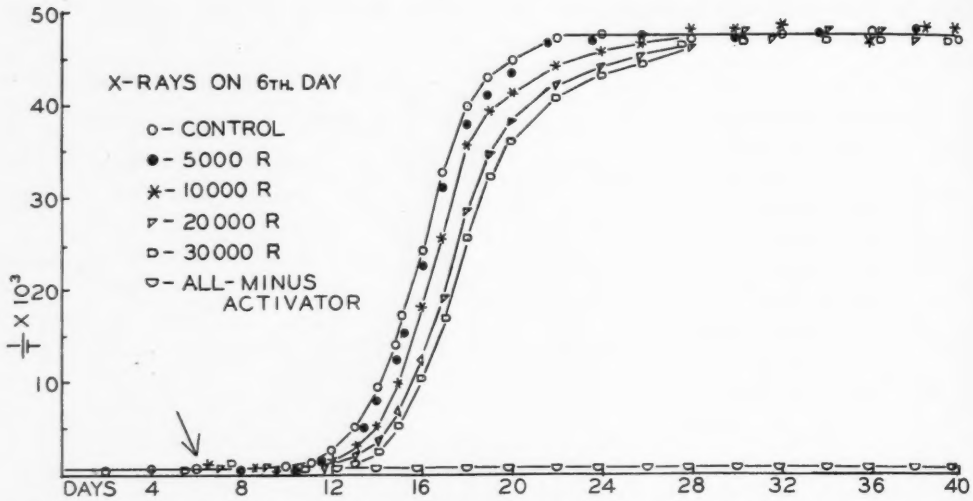


Fig. 6. Effects of intensive treatment of *M. differentialis* eggs with roentgen rays on the formation of tyrosinase beginning six days after irradiation. Arrow indicates day of treatment; ordinate, reciprocal of time for half life; abscissa, days of development at 25° C.

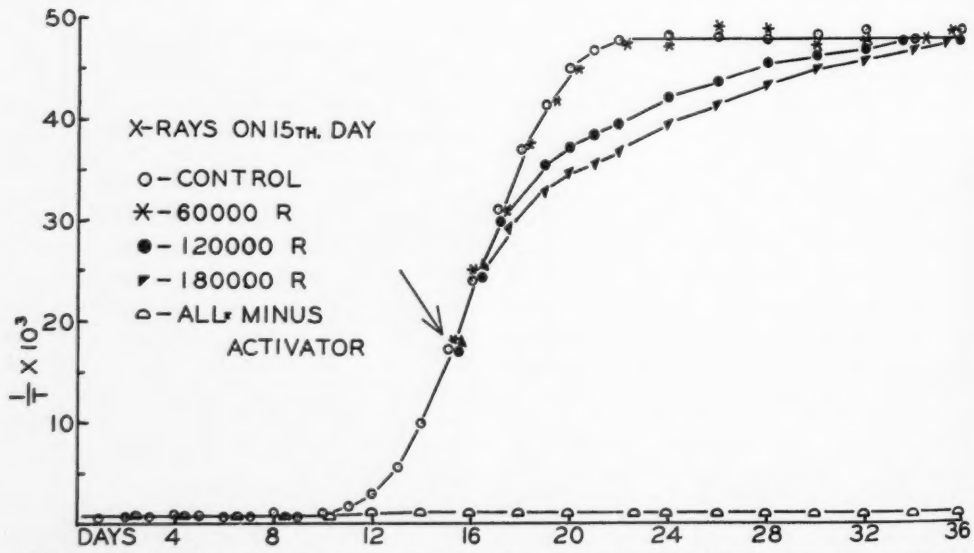


Fig. 7. Effects of large doses of roentgen rays at the time of most rapid tyrosinase production on the rate of its formation. Arrow indicates day of irradiation; ordinate, reciprocal of time for half life; abscissa, days of development at 25° C.

At this time the several series of eggs were given doses of 60,000, 120,000, and 180,000 in rate of formation of the tyrosinase (Fig. 7). The effect appears in three days

and the maximum concentration of the enzyme is attained about two weeks later than the controls. Under none of the above conditions did any activation of the tyrosinase occur.

DISCUSSION

Figures 1 and 2 show that exposure of tyrosinase solutions to from 500 to 5,000 r of roentgen rays does not affect the activated or the non-activated enzyme during periods from 10 minutes to 10 days after irradiation. This may seem to be in disagreement with the results of investigations on the effects of irradiation on other enzymes (Clark and Northrop, 7; Richards, 15), but it has been shown that tyrosinase is an exception to the rule in that it was not affected by the beta or gamma rays of radium (Willcock, 17). No evidence has been presented to indicate that it should be altered by roentgen irradiation.

The absence of any effect on the contained tyrosinase after extensive irradiation of developing and inactive eggs has been demonstrated (Fig. 3). Physiologically inactive eggs that presumably would be in no position to restore any destroyed enzyme were given 10,000, 20,000, and 30,000 r but with no effect (Fig. 3, *A*). The lack of any activation also indicated that the irradiation neither enabled the naturally occurring activator to act on the enzyme nor served in an activating capacity itself. Keeping physiologically active eggs at 0° C. after exposure to 30,000 r (Fig. 3, *C*) constituted an effort to simulate the inactive condition of diapause eggs. Similarly, in this case the low temperature would tend to prevent the restoration of any destroyed enzyme and the tyrosinase might also be in a more susceptible condition. However, there was no effect on the tyrosinase.

The same negative results after treatment of developing eggs with 30,000 r (Fig. 3, *B*) may be taken to indicate that the embryo is not essential for the maintenance of tyrosinase activity and concentration. In less than two weeks after irradiation the embryos ceased to develop and none of them hatched. Within several weeks they died and disintegrated, during which time the tyrosinase remained unaffected.

The effects of roentgen irradiation on tyrosinase production in the egg are of considerable interest. Evans (9) has shown that the exposure of five-day eggs to 500 r results in the complete destruction of all embryos. It is rather surprising then that twice as much irradiation on the same day has no effect on tyrosinase production (Fig. 5). The exposure of older eggs to large doses of roentgen rays (Figs. 6 and 7) also results in the destruction of the embryos but has little or no effect on the subsequent formation of the enzyme. It is then apparent that tyrosinase is produced in the same amount and at the same rate after the destruction of the embryo.

The elimination of the embryo as a source of tyrosinase leaves two other possible sources, namely, the yolk cells and the serosa cells. It is known that these cells are extremely resistant to roentgen rays at times when the embryo proper is readily affected.[3] The enormous increase in resistance to roentgen irradiation during the first two days of development (Fig. 5) may be suggested as the key to which of these two types of cells serves as the source of enzyme. In a study of the early embryology (Slifer and King, 16) it has been shown that during the first day nearly all of the segmentation nuclei are scattered in the yolk in the process of migrating to the peripheral protoplasm, but by the second day this process is practically completed. It appears then that the increased resistance to irradiation occurs at the same time as the segmentation nuclei are taken into the peripheral protoplasm to form serosa cells. These cells are secreting the cuticle during the sixth day and hence are especially active. However, it was found that large amounts of roentgen radiation at this time did not prevent the formation of the cuticle (Fig. 6). Enormous amounts of radiation at a time when tyrosinase formation is occurring very rapidly gave similar results (Fig. 7), showing that the cells

which produce the enzyme are also strikingly resistant to irradiation even though in a state of considerable activity. This evidence does not completely eliminate the yolk cells as a source of tyrosinase, but suggests that this function is performed by the serosa cells in the orthopteran egg.

Mention may be made of a few general reactions of these cells to roentgen irradiation. It may be deduced (Fig. 4) that the segmentation nuclei which are in the process of migration during the first day are destroyed by 1,000 and 2,000 r. This is indicated by the fact that these doses completely prevent tyrosinase formation. The linear nature of the curves representing the effects of 250 and 500 r may be considered to indicate (1) that only those nuclei in the process of migration were affected, or (2) that what peripheral nuclei were affected did not recover. The nearly parallel curves in Figure 6 suggest complete recovery from the effects of those amounts of irradiation. The converse is true in Figure 7, where the attainment of control activity of tyrosinase takes place through the action of unaffected cells rather than by recovery from the irradiation. The extraordinary ability of these cells to resist the effects of roentgen irradiation is attested to in that during cuticle secretion (about the sixth day) and at the time of most rapid tyrosinase production (fifteenth day), 10,000 to 180,00 r are required to cause any measurable effects.

SUMMARY AND CONCLUSIONS

1. A description of the effects of roentgen rays on the enzyme, tyrosinase, and on its production in the eggs of the grasshopper, *Melanoplus differentialis*, have been presented.

2. Roentgen rays in the dosage supplied (500, 1,000, 2,000, 5,000 r) and in intervals of from 10 minutes to 10 days after irradiation produced neither inactivation nor activation of tyrosinase solutions prepared from grasshopper eggs.

3. Intensive roentgen irradiation (10,000 to 30,000 r) of diapause (inactive) eggs, of active eggs, kept at low temperature to prevent development, and of actively developing eggs failed to have any effect on the activity or concentration of the contained tyrosinase after it has reached maximum concentration in the eggs.

4. That tyrosinase may be produced in the absence of the embryo is shown by total destruction of the embryo (1,000 r on the fifth day) without affecting the subsequent tyrosinase production.

5. There is a remarkable increase in resistance to radiation in the tyrosinase-producing cells, from the first day after laying, when exposure to 1,000 r completely prevents tyrosinase formation to a day later, when 1,000 r reduces its formation but slightly. On the second day more than 30,000 r are required to lower the enzyme concentration to 50 per cent of the control value.

6. The fact that during this time of increasing resistance the segmentation nuclei are migrating outward to combine with the peripheral protoplasm to forms erosa cells suggests that these latter cells may be the source of the tyrosinase.

7. The resistance to roentgen irradiation of the tyrosinase-producing cells is so great that they tolerate dosages of 5,000 to 30,000 r five days before formation of the enzyme begins or 60,000 to 180,000 r at the time of most rapid formation of the tyrosinase.

REFERENCES

(1) AGULHON, HENRI: Action des Rayons Ultraviolets sur les Diastases. Comptes Rend., **152,** 398–401, 1911.

(2) Idem: Sur les Mechanisme de la Destruction des Diastases pare le Lumière. Comptes Rend., **153,** 979–982, 1911.

(3) BODINE, J. H.: Factors Influencing the Rate of Respiratory Metabolism of a Developing Egg (*Orthoptera*). Physiol. Zool., **2,** 459–482, 1929.

(4) BODINE, J. H., and BOELL, E. J.: Enzymes in Ontogenesis (*Orthoptera*). I.—Tyrosinase. Jour. Cell. and Comp. Physiol., **6,** 263–275, 1935.

(5) BODINE, J. H., ALLEN, T. H., and BOELL, E. J.: Enzymes in Ontogenesis (*Orthoptera*). III.—Activation of Naturally Occurring Enzymes (Tyrosinase). Proc. Soc. Exp. Biol. and Med., **37,** 450–453, 1937.

(6) BODINE, J. H., and ALLEN, T. H.: Enzymes in Ontogenesis (*Orthoptera*). IV.—Natural and Artificial Conditions Governing the Action of Tyrosinase. Jour. Cell. and Comp. Physiol., 1938, in press.

(7) CLARK, HARRY, and NORTHROP, J. H.: The Inactivation of Trypsin by X-rays. Jour. Gen. Physiol., **9,** 87–96, 1925.

(8) DUGGAR, BENJAMIN M.: Biological Effects of Radiation. McGraw-Hill, New York, 1936.

(9) EVANS, T. C.: Qualitative and Quantitative Changes in Radiosensitivity of Grasshopper Eggs during Early Development. Physiol. Zool., **9,** 443–454, 1936.

(10) HENRI, VICTOR, and MAYER, ANDRÉ: Action des Radiations du Radium sur les Colloides, l'Hemoglobine, les Ferments et les Globules Rouges. Comptes Rend., **138,** 521–524, 1904.

(11) NARAYANAMURTI, D., and AYYAR, C. V. R.: Studies in Enzyme Action. Part IV.—Tyrosinase I. Jour. Ind. Inst. of Sci., **12*A*,** 105–129, 1929.

(12) NARAYANAMURTI, D., and RAMASWAMI, C. V.: Irradiation of Dolichos Tyrosinase. Biochem. Jour., **24,** 1655–1658, 1930.

(13) PINCUSSEN, L., and HAMMERICH, T.: Fermente und Licht. XVII.—Über Tyrosinase. Biochem. Zeit., **239,** 273–289, 1931.

(14) PRZIBRAM, H., and DEMBOWSKI, J.: Konservierung der Tyrosinase durch Luftabschlusz. Arch. für Entwick., **45,** 260–272, 1919.

(15) RICHARDS, A.: The Effect of X-rays on the Action of Certain Enzymes. Am. Jour. Physiol., **35,** 224–238, 1914.

(16) SLIFER, E. H., and KING., R. L.: Insect Development. VII.—Early Stages in the Development of Grasshopper Eggs of Known Age and with a Known Temperature History. Jour. Morph. and Physiol., **56,** 593–598, 1934.

(17) WILLCOCK, E. G.: The Action of Radium Rays on Tyrosinase. Jour. Physiol., **34,** 207–209, 1906.

VARIATIONS IN POSITION OF THE NORMAL COCCYX

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DURING the routine examination of patients in the X-ray Department of Bellevue Hospital for various pathological conditions unrelated to the sacrum or coccyx, it often has been noted that the coccyx was subject to many variations in position both in the sagittal and transverse planes. This observation has been common to all roentgenologists for many years and does not present any new information. However, the medico-legal aspect of such variations in position has been more troublesome. It has been the experience of many roentgenologists who were called in to testify in courts concerning the possibility of traumatism of the coccyx to hear conflicting opinions as to the significance of the various coccygeal malpositions. It was, therefore, thought advisable that a study of the normal coccyx be undertaken to show that variations in position do exist and to study their incidence and degree.

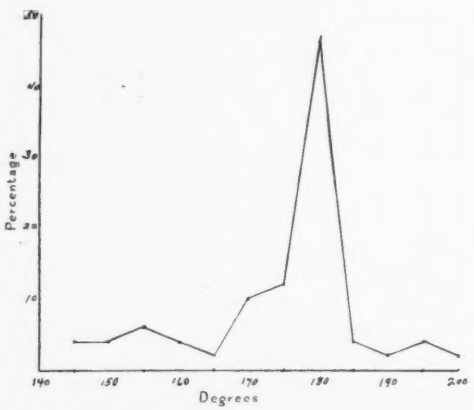

Fig. 1. Graph showing the degrees of angulation of the coccyx and the percentage of individuals with variations.

A search of the medical literature shows that the normal coccyx has not been given much space or attention. The various current textbooks on anatomy describe it as the most distal portion of the vertebral column consisting usually of four, though occasionally three or five, rudimentary vertebræ. The texts go on to describe the configuration and structure of the various segments, but little, if any, comment is made upon the occasional anomalies of position. Previous to the advent of the x-ray, the references to the coccyx in the literature are confined primarily to discussions of trauma to the coccyx; especially posterior displacement and the treatment therefore. Various textbooks on roentgenology have commented, if somewhat briefly, on the coccyx and its relations to the sacrum. Attention has been called to the fact that merely because there is a deviation of the coccygeal segments it does not necessarily follow that it is due to trauma. H. F. Johnson has pointed out that variations in contour, length, and alignment are common. The last three or four segments are usually fused together and are frequently angulated forward at various angles. Lateral deviations are not uncommon, but are of no significance unless associated with complete luxation at the sacrococcygeal articulation.

In our study, 100 adults were chosen at random from the usual run of patients in our department with the prerequisite that they be free of any symptoms referable to the spine and that there be no history of trauma to the sacrum or coccyx. These patients were x-rayed in the anteroposterior and lateral positions. Lateral deviations were measured by drawing lines through the central planes of the sacrum and coccygeal segments and noting the angle between them. In the sagittal plane, the angulation was determined by drawing a line through the median planes of the last sacral segment, the first and second coccygeal segments, and measuring the angles between them. The angles were measured to the nearest five-degree deviation, as it was felt that this was compat-

ible with the margin of error in this particular method. In the transverse plane, 16 per cent showed a measurable amount of lateral deviation, varying from five degrees to 65 degrees. Of these, 12 cases showed a small variation of 15 degrees or less. Of the remainder, one case showed a deviation of 65 degrees, and one of 60 degrees. There were, in addition, two cases of double angulation; that is, angulation at the sacrococcygeal articulation and also at the first intercoccygeal articulation. In one case there was a 15-degree angulation at the first articulation and one of 40 degrees at the second. In the other, there was an angulation of ten degrees at the first articulation and of 35 degrees at the second.

The data gathered from the lateral views are presented graphically in Figure 1. The deviations at the sacrococcygeal articulation correspond closely to the distribution found in the normal curve of probability. The group designated as measuring 180 degrees had the central planes either in a straight line or so close to it that for the purposes of this study they were considered as being on a straight line. In this series only the cases on the extreme left side of the curve should be considered grossly as angulations, comprising only about 5 per cent of the cases. The smaller angles in the other cases represented merely an increasingly deeper curve in the sacrum and coccyx.

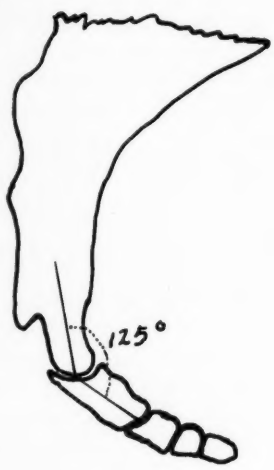

Fig. 2.

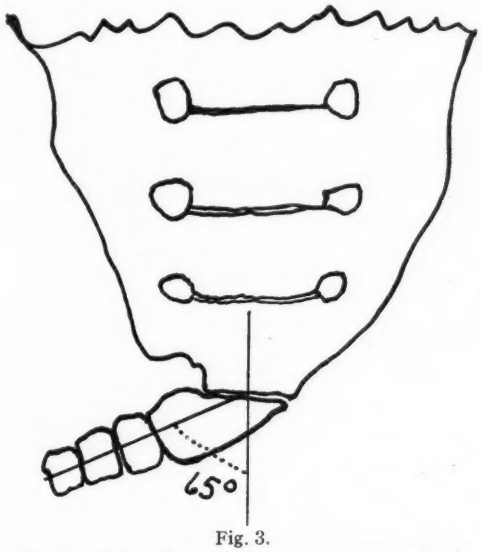

Fig. 3.

Fig. 2. Method of measuring the degree of angulation of the coccyx in relation to the sacrum, in the sagittal view.

Fig. 3. Congenital anomaly of the sacrococcygeal junction. Method of measuring the degree of the lateral angulation of the coccyx in the anteroposterior view.

The angles demonstrated between the first and second coccygeal segments closely approximated that shown for the sacrococcygeal articulation except that in none of the cases studied was there any with posterior angulation, this apparently being confined to the sacrococcygeal articulation. Due to the deepening of the sacrococcygeal curve the angles of the greatest number of cases ranged between 160 degrees and 170 degrees, with a few cases scattered between 135 degrees and 160 degrees. There were two cases showing an angle of 125 degrees and three of 130 degrees, that were considered to be angulated. In the entire series there were six cases that showed posterior angulation at the sacrococcygeal articulation and anterior angulation at the

first coccygeal articulation. There were only two cases that showed angulation in both the sagittal and transverse planes at both the sacrococcygeal and first coccygeal articulations.

CONCLUSIONS

1. That angulations at the sacrococcygeal and first coccygeal articulations are to be found in the normal spine.
2. That the cases presenting an appreciable variation constitute only a small percentage of the total number.
3. That the variation may occur either in the transverse or sagittal plane and, more rarely in both.

BIBLIOGRAPHY

(1) Robinson, A., Editor: Cunningham's Textbook of Anatomy, Oxford Press, 1914.
(2) Gray, Henry, Editor: Lea & Febiger's Anatomy of the Human Body, Philadelphia, 1930.
(3) Jackson, C. M., Editor: Morris' Human Anatomy. P. Blakiston's Son & Co., Philadelphia, 1914.
(4) George, A. W., and Leonard, R. D.: The Vertebræ. Paul B. Hoeber, Inc., New York, 1929.
(5) Friedman, Lewis J.: Textbook of Diagnostic Roentgenology. D. Appleton-Century Co., New York, 1937.
(6) Johnson, H. F.: Derangements of the Coccyx. Nebraska Med. Jour., **21**, 451–457, December, 1936.
(7) Cyriax, E. F.: Minor Displacements of the Coccyx. Glasgow Med. Jour., **98**, 118–125, August, 1922.
(8) MacDonald, A.: Backward Projection of Coccyx with Ankylosis at Sacrococcygeal Joint. Edinburgh Med. Jour., **31**, 1885–1886.
(9) Walker, J. E.: The Coccyx. Trans. New York Med. Assn., **15**, 1898.
(10) Stone, R. E.: Congenital Absence of Coccyx and Congenital Backward Deviation and Shortening of Coccyx. Arch. Ped., **34**, 1917.
(11) Steindler, A.: Diseases and Deformities of the Spine and Thorax. Mosby, St. Louis, 1929.

OSSEOUS GROWTH AND DEVELOPMENT

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IN the Fall of 1930 the Department of Child Hygiene, of the School of Public Health of Harvard University, in cooperation with the Boston Lying-in Hospital, and the Children's Hospital of Boston, began a study concerned with the growth and development of normal children.

Only such children were included whose mothers had been followed in the Prenatal Clinic and subsequently delivered at the Lying-in Hospital. Obviously abnormal children were excluded from the series. From the time of birth these children were examined at frequent intervals and complete records kept of various factors having a bearing on their health, growth, and development.

In addition to the careful clinical observations, roentgenograms of practically the entire body were made within 48 hours of birth. During the first year these were repeated at three-month intervals and thereafter at six-month intervals. Supplementary roentgenograms were sometimes taken between these periods.

Two hundred and twenty-eight infants have had roentgenograms at birth (112 girls and 116 boys). The decreasing smaller number of cases at subsequent age periods indicates that only a percentage of these children have yet reached any given age period. For various reasons a few of these cases have been lost or dropped, but the relative proportion of boys and girls has remained practically the same. The study is still in progress and we hope ultimately to have a composite picture of normal growth and development of this group from birth to young adult life.

All particulars will eventually be worked out in detail; correlating clinical, anthropometric, and roentgenologic data, but completion must necessarily await a good many years. In the meantime we felt it would be worth while to present certain information already available, which is concerned with osseous growth and development.

In any attempt to evaluate the bone age from roentgenograms it is not only important to know the time at which the different osseous centers appear but also their size and contours at the different age periods. In addition to the variation consequent to age, there are fairly wide variations in normal children of the same age, commonly referred to as "normal" variations.

Tables or graphs can give only a very rough idea of these variations and for essential features there is no good method of depicting these changes except by reproductions of roentgenograms or by reproductions of accurate black and white drawings of roentgenograms. In this paper we have used drawings because they can be reduced in size to save space and can be referred to easily.[1]

Ideally we might have reproduced the entire skeleton but for practical purposes the bones of the hands (including wrists) and bones of the feet were in most instances adequate. This is because in these structures we find a large number of ossification centers which are constantly changing in size and contour. Furthermore, they are easy to obtain on roentgenograms and easy to reproduce on paper.

In this study an attempt was made to examine all children on the exact day listed on the charts and although this was not entirely possible, time variations were

[1] These reduced drawings are obviously not as accurate as original roentgenograms but serve as a practical compromise between publication space requirements and bone detail. They are intended to show features for which, after all, we have no absolute standards.

BOYS

NUMBER OF CASES	Birth 116	6 mos. 92	1 yr. 101	1½ yrs. 81	2 yrs. 90	2½ yrs. 78	3 yrs. 78	3½ yrs. 70	4 yrs. 66	4½ yrs. 55	5 yrs. 52	5½ yrs. 40	6 yrs. 31	6½ yrs. 19
90TH PERCENTILE (ADVANCED)														
50TH PERCENTILE (AVERAGE)														
10TH PERCENTILE (SLOW)														

GIRLS

NUMBER OF CASES	Birth 112	6 mos. 97	1 yr. 101	1½ yrs. 80	2 yrs. 86	2½ yrs. 75	3 yrs. 81	3½ yrs. 67	4 yrs. 61	4½ yrs. 56	5 yrs. 53	5½ yrs. 41	6 yrs. 32	6½ yrs. 17
90TH PERCENTILE (ADVANCED)														
50TH PERCENTILE (AVERAGE)														
10TH PERCENTILE (SLOW)														

FROM

THE CENTER FOR RESEARCH IN CHILD HEALTH AND DEVELOPMENT

H. C. STUART, M.D., DIRECTOR

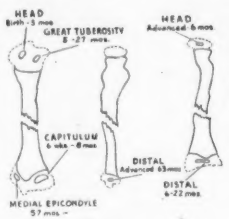
HARVARD SCHOOL OF PUBLIC HEALTH

E. C. VOGT, M.D. AND VERNETTE S. VICKERS

Appearance of other centers in upper extremity which have been seen between birth–6½ years. (Range indicates 10TH and 90TH percentiles)

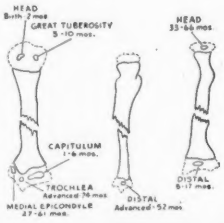
BOYS

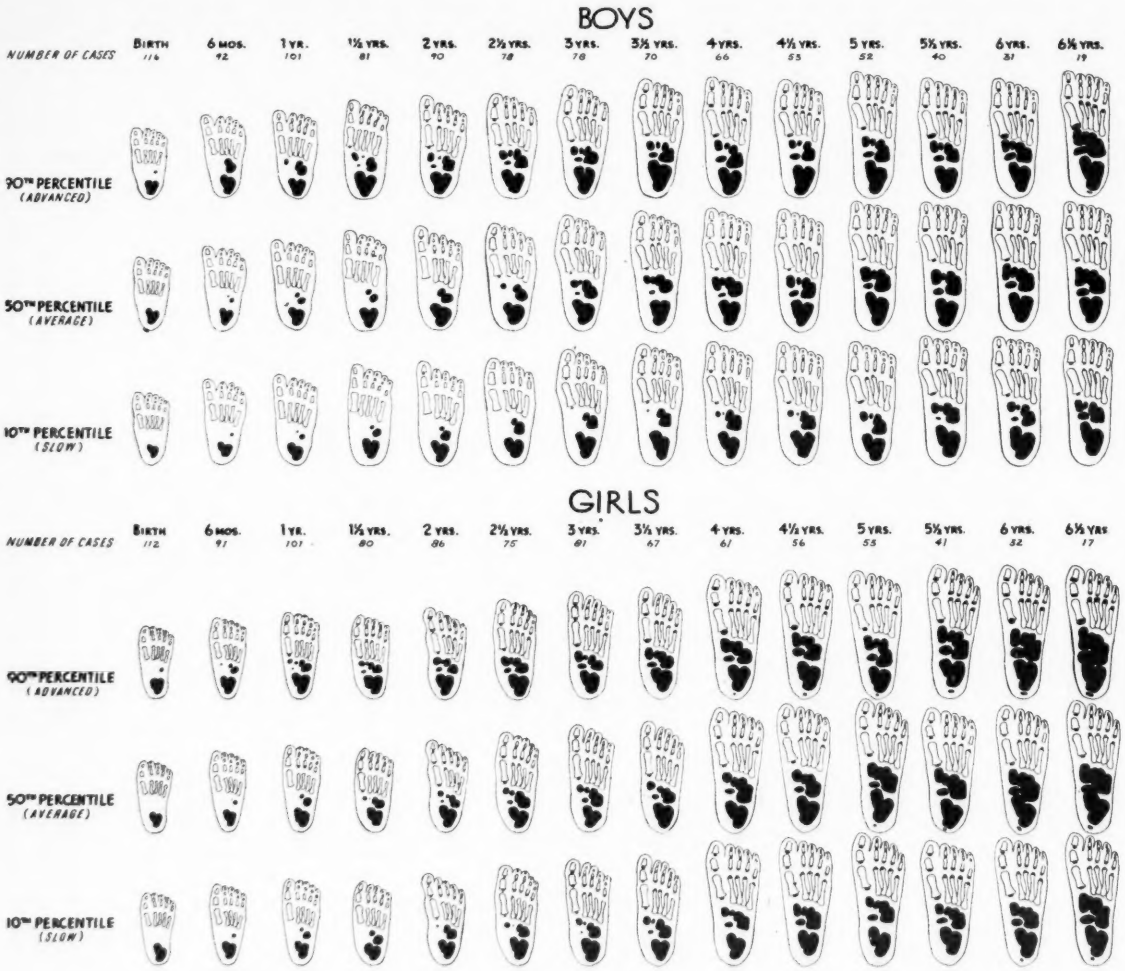
Humerus Ulna Radius



GIRLS

Humerus Ulna Radius





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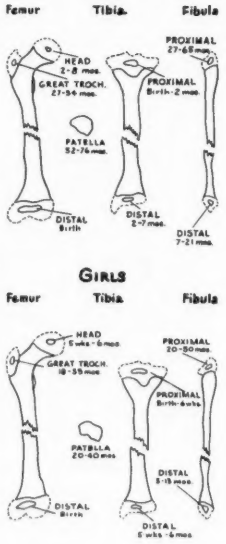
Appearance of other centers in lower extremity which have been seen between birth–6½ years. (Range indicates 10TH and 90TH percentiles)



seldom as much as plus or minus one week and never more than two weeks.

Since space does not permit listing individually all extremes of development, and since we do not feel that all extremes are desirable in a reference work of this character, we have chosen to leave out the 10 per cent of the extremes at both the upper and lower limits. This we admit is arbitrary but, if understood, we feel that it gives a good idea of the variations which may be considered well within normal limits, and leaves out those which might be considered freaks.

Only native-born whites were included in this series. No attempt was made to segregate according to ancestral nationality but with very few exceptions the parents were born in the United States, Canada, or one of the northern European countries.

In the accompanying charts average development is indicated by the middle row, or as the fiftieth percentile (half of the children have reached this stage of development). The upper and lower rows (ninetieth percentile and tenth percentile) may be said arbitrarily to represent the limits of what we choose to call "normal" variations, *i.e.*, 80 per cent of our children fall within these limits. The ninetieth percentile indicates the stage of development which only 10 per cent of the children have reached (advanced), while the tenth percentile indicates the stage which 90 per cent have reached at any given age period (slow).

Boys and girls are listed separately and it can readily be seen that girls through this age period (birth to six and one-half years) are, in general, somewhat more advanced as far as osseous development is concerned, than are the boys.

When one compares the hands and feet of any particular child with these charts he may find that the hand age does not correspond identically with the foot age, but these variations have to be taken into consideration in arriving at the most nearly correct estimate and a certain amount of judgment has to be exercised. As previously mentioned, there is no standard osseous development and in all evaluations consideration must be given to the possibilities of ordinary or "normal" variations.

Note.—A full report of the studies being conducted at the Center for Research in Child Health and Development, of which these roentgenograms are a part, is soon to appear in the Monograph Series of the Society of Research in Child Development.

COARCTATION OF THE AORTA

THREE CASES WITH NECROPSY FINDINGS IN ONE

By TOBIAS B. WEINBERG, M.D., *and* CHARLES GARTENLAUB, M.D., *New York City*

From the Department of Roentgenology, Metropolitan Hospital, New York City

COARCTATION of the aorta is the term applied to the congenital stricture of the arch of the aorta, usually below the origin of the left subclavian artery. It is not an uncommon anomaly and Morgagni, in his "De Sedibus et Causis Morhorum" (1761), was the first to call attention to this condition although his case is a very doubtful one. The first authentic case with typical findings was described by a French prosector, Paris, in 1794. Meckel (1) first observed erosion of the ribs, but his illustration shows these lesions on the superior costal border, while the predominant lesions as generally reported are found on the inferior border of the posterior portion of the ribs. Railsback and Dock (2) clinically applied this information over one hundred years after Meckel reported rib erosion.

Bonnet (3), in 1903, classified the cases into the infantile and adult types as follows:

1. The *adult type* he defines as consisting of cases usually seen after infancy is passed, in which the coarctation is a more or less abrupt constriction of the aorta at or near, often a little below, the insertion of the ductus arteriosus. It is never seen in the fetus nor at birth before the closure of the ductus has begun. Skoda suggested that in this type a portion of the tissue peculiar to the ductus arteriosus extends into the adjacent aortic wall and, as the atrophy of this tissue occurs, it results in constriction or occlusion of the aorta. The process is a comparatively slow post-natal development and adequate collateral circulation has time to become established.

2. The *infantile type*, mostly seen in the new-born in which there is a diffuse narrowing, or a complete absence of the isthmus (that part of the aorta between the left subclavian artery and the junction with the ductus Botallo). This form is commonly associated with other congenital anomalies and is not compatible with adult life. Bonnet feels that this type is developmental in origin. Blackford, in a review of 26 atypical examples of this condition in infants, believes that the adult type is also due to maldevelopment rather than to post-natal contraction of the Botallian tissue in the wall of the aorta, but he feels that the above classification, though not precise, is convenient both morphologically and clinically.

Hamilton and Abbott (5) and Blackford (4) recently analyzed all the reported cases (200), with autopsy, 12 of which had been diagnosed antemortem. They listed the following points on which a diagnosis of coarctation of the aorta may be made clinically:

1. A diminished blood pressure in the lower extremities, with retardation and diminution or complete absence of the femoral pulse, in the presence of a contrasting hypertension in the upper extremities and a full hard radial pulse.

2. The evidences of an extensive collateral circulation in the upper part of the body. It may be added that the only evidences of collateral circulation clinically may be prominent blood vessels in the neck. The symptomatology varies a great deal, Abbott (5) placing the patients in three groups:

(*A*) Those in whom symptoms are absent.

(*B*) Those in whom symptoms are late in developing. These symptoms are flushing of the face, profuse sweating in upper portion of the body, headaches, tinnitus, and dizziness, all of which can be associated with the hypertension in the upper extremities, head, and neck. In this group sudden rupture of the

heart, aorta, or vertebral arteries occurs.

(*C*) The group in which symptoms are present throughout life. These are usually the symptoms of myocardial failure which often results from secondary chronic valvular disease.

In contrast to these inconstant subjective features of coarctation of the aorta, the physical signs are diagnostic in all the cases prior to terminal complications.

Since most of the symptoms were referable to increased arterial pressure in the upper part of the body, the effect upon the activity of the thyroid gland is of interest. Ulrich (6) reported two cases in which there was an increased basal metabolic rate. He suggests that symptoms of hyperthyroidism with increased blood pressure in the young should make one alert as to the possibilities of coarctation.

Prognosis in this condition is difficult to determine for an individual case but, in general, may be based on compilations by Abbott, (7), who found the average age to be 32 years, with a range from three to 92 years. The cause of death was as follows:

Congestive heart failure	60
Sudden heart rupture	2
Rupture of aorta	38
Cerebral complications	26
Bacterial endarteritis	14

Evans (8) examined 26 cases at necropsy and the average age was approximately 11.4 years, with a slightly higher incidence in the male. Other developmental anomalies may accompany this congenital deformity of the aortic arch. The cause of death in his series was as follows:

	No.	Average Age
Heart failure	13	2.11 years
Bronchopneumonia	4	4 years
Bacteremic endocarditis	2	27.6 years
Rupture of mycotic or false aneurysm	3	26 years
Congenital stenosis of intestine	2	6 days
Pulmonary embolism	1	60 years
Foreign body in bronchus	1	1.5 years

Although most of Abbott's patients died of cardiac insufficiency, Lewis (9) points out that cases of coarctation are the best evidence that prolonged overwork of the heart in itself does not cause myocardial failure. He observed patients in whom the heart continued to beat for as long as 16 years against a systolic pressure of 200 and a diastolic of 100. He states that only 25 per cent of the deaths in coarctation are attributable to congestive heart failure and in those cases infectious diseases or changes due to advancing age are responsible for the sudden incompetence of the heart. The important fact, as Lewis sees it, is that failure is not inevitable.

Roentgenological examination of the thorax is of the utmost importance in that the findings are pathognomonic, each being explained on an anatomico-pathologic basis. Fray (10) covers this aspect fully, dividing the evidences into:

1. Direct signs = due to atresia.
   - (*a*) Absence of aortic knob in postero-anterior view: not pathognomonic;
   - (*b*) Defect or discontinuance of the aortic arch in its descending portion in left oblique view: this is pathognomonic.
2. Indirect or secondary signs.
   - (*a*) Hypertrophy of the left ventricle: in 75 per cent of the cases;
   - (*b*) Dilatation of proximal portion of the aorta;
   - (*c*) Erosion of the ribs: this is pathognomonic.

   This erosion of the ribs by the dilated intercostal arteries is very important and their characteristics are as follows:
   - (1) Multiple; may be more than one on one rib;
   - (2) Only lower margins of ribs involved;
   - (3) Bilateral, usually involving the posterior portions of the ribs as far as the posterior axillary lines;
   - (4) Sulcation is smoothly curvilinear, never rough or angulated.
   - (5) No other alterations of the ribs;

(6) No, or little, evidence of new bone formation: upper line may show increased density;
(7) No pathological fracture.

CASE REPORTS

Three cases of coarctation of the aorta are herewith reported: two are new additions to the literature; the third case has been reported previously by Finesilver (11), but is added because of roentgenological findings not mentioned in his paper.

Case 1. A. S., a 23-year-old American-born white male entered the hospital on Feb. 11, 1935, upon advice of a physician who, treating him a month before for an upper respiratory infection, had told him that he had a high blood pressure. His family and past history are irrelevant. He denied ever having had any venereal diseases and this was subsequently confirmed by laboratory studies. He stated that he suffered from dyspnea but no orthopnea. Aside from occasional sharp precordial pains at intervals of three or four months, the patient has had no other cardiac symptoms. His dyspnea has persisted since he was 15 years of age, but has never handicapped him. He has also had occasional palpitation, but no throbbing. He coughs only when he has an upper respiratory infection.

Physical examination revealed a well developed, well nourished male, not acutely ill. The eyes, ears, nose, and throat were negative. The neck showed a marked carotid pulsation, with cervical adenopathy. There was a moderate venous engorgement of the right upper extremity. The lung-fields were clear. The heart showed enlargement to the left, 12 cm. and in the sixth intercostal space. There was a systolic blow at the apex. The aortic area showed systolic and diastolic roughening, with a split first sound. The pulmonic area showed a systolic blow transmitted to the veins of the neck. Examination of the abdomen, genitalia, and nervous system was negative. Blood pressure of the right upper extremity revealed a systolic of 150 over a diastolic of 90; the left upper extremity had a systolic of 100 over a diastolic of 90. The readings three days later were 170/90 and 98/90, respectively. Blood pressure readings over the lower extremities were not obtainable. The venous pressure of the right upper extremity was 6.0 cm. and over the left upper extremity was 3.5 cm. Roentgenographic examination (Fig. 1) showed an enlarged cardiac shadow with left ventricular preponderance, absence of the aortic knob, and notching of the lower borders of the right ribs posteriorly.

Fig. 1. Case 1.

Case 2. E. H., an American-born 41-year-old white female, entered the hospital on Dec. 19, 1935 with a history of onset five days before of cough and pain in the right chest in its lower portion. The pains were aggravated by coughing and breathing. For three days she raised a whitish, blood-streaked sputum associated with a fever. Her family history revealed that her father had died at 70 because of a cerebral apoplexy and her mother at 72 from heart disease. Two brothers are living and well, and one sister who, she states, has heart disease. She has had measles, mumps, chicken-pox, and whooping cough. At the age of 16 she had a

Fig. 2. Case 2.

shortness of breath and pains in both legs and was then told by a physician that she had a "leaking heart." Since then she has had a dyspnea on exertion, with a swelling of the feet and ankles. In 1930 she had a pleurisy of the left chest and was hospitalized for six weeks, but required no aspiration. Her menstrual history is normal: she was married at 25. She states that her husband has had a chronic bronchitis for 20 years, coughing continually and having frequent hemoptyses. She denies any venereal infection. She has a 15-year-old child and has had three miscarriages. In 1925 she had a suspension of the uterus operation. She states that night sweats have been frequent for the past year. At the present time she weighs 102 pounds, having lost four pounds since 1934. As regards her habits, she vomits occasionally, has a poor appetite, and is at times constipated. There are no urinary disturbances.

Physical examination shows an acutely ill, malnourished adult female with a malar flush, slight cyanosis of the lips, coughing, and dyspneic. The temperature is 103, pulse 120, and the blood pressure 180 over 70. Pupils react to light and accommodation, conjunctiva pale, and the pharynx injected. The tongue is dry and coated, teeth show poor hygiene. The ears are negative and the nose shows nares patent and the septum intact. The neck shows no adenopathy, the thyroid not enlarged, and the trachea shifted slightly to the left. The thorax shows a lag of the right chest, dullness below the third rib anteriorly and D5 posteriorly. There are bronchial breath sounds anteriorly with crepitant râles. Posteriorly there are diminished bronchial-to-absent breath sounds over the right middle and lower lobes. There is a slight impairment to percussion over the left infraclavicular region. The heart is greatly enlarged to the left, right, and downward. The sounds are transmitted and heard throughout the entire chest. The aortic area shows a systolic murmur transmitted to the neck, and also a short diastolic. At the apex there is a presystolic and systolic. A double murmur is heard to the right of the sternum below the fourth rib and also a suggestion of a friction rub. The heart rate is rapid and has a gallop quality. The abdomen is soft and relaxed, the liver being felt one inch below the costal margin, and there is an old operative scar. The extremities reveal no edema, clubbing, varicosities, or deformity. The impression at this time is a right pleural effusion with an underlying consolidation of the right middle and lower lobes, a mitral and aortic stenosis and insufficiency on a rheumatic basis, and a possible pericarditis.

The next day a roentgenographic examination (Fig. 2) showed definite clouding in the lower half of the right lung-field, with increased markings above; the left lung-field was clear; the cardiac shadow was enlarged, with a left ventricular preponderance, and the ribs showed notching of their lower borders posteriorly. The conclusions were: right pleural effusion with underlying consolidation with the possibility of a pulmonary infarct and coarctation of the aorta, suggesting further study for corroborative evidence.

On Dec. 23, 1935, the patient had a

crisis and her temperature dropped to normal but two days later there were signs of a massive right basal effusion. On aspiration, 350 c.c. of a dark yellowish fluid with a ground-glass sediment was removed. At this time no femoral, popliteal, or tibial pulsations or blood pressure readings in the lower extremities were obtainable. E.K.G. studies showed the following:

Auricular rate	100 per minute
Ventricular rate	100 per minute
P-R interval	.20 sec.
Q.R.S.	.08 sec.
Deviation of electrical axis left	
Lead 1	R slurred
Lead 2	R slurred, S-T depressed
Lead 3	P isoelectric, S slurred, T low

E.K.G. impression: Sinus tachycardia-myocardial damage.

The patient continued to improve and on Jan. 5, 1936, a few days before discharge, blood pressure readings showed the following:

Right arm 200/76	Left arm 194/72
Right leg 94/80	Left leg 92/76

Case 3. W. L., a 26-year-old American-born white male, truckman by occupation, was admitted on March 22, 1934. The patient was unable to co-operate or answer questions intelligently and the history was obtained from his sister. He had been normal apparently until two and one-half years before, when he suddenly developed a paralysis of the left arm followed by a complete left hemiplegia and later by a right hemiplegia. He had been in the New York Hospital on three different occasions and his condition has become progressively worse. His birth was normal, he being the last of eleven children, and he was educated through elementary school.

Physical examination showed a fairly well-developed and well-nourished male, lying quietly in bed. His manner is pleasant, with the peculiar smile of the mentally deficient. He laughs at times and his speech is restricted to a few words. There is no jaundice, dyspnea, or cyanosis, and he is incontinent. The head and neck show no deformities. The eyes show the right pupil greater than the left: both

Fig. 3. Case 3.

are regular and react poorly to light. The fundi show pallor of disks with a moderate tortuosity of the vessels; no hemorrhages or exudates seen. Vision cannot be estimated due to the patient's mental status. The nose, ears, and mouth are negative. The neck shows a pulsating vessel overlying the area normally occupied by the thyroid isthmus. The trachea is in the mid-line. The thorax is symmetrical, with slight respiratory movements, and the lung-fields are clear. The heart is enlarged downward and to the left, with a harsh systolic murmur over the precordium and vessels of the neck. It is regular in rate and rhythm except for occasional systoles. The blood pressure reading in the right arm is 270/145 and in the left arm it is 260/145. No readings can be elicited in the lower extremities. The readings taken at the New York Hospital at the time of his last admission there on Aug. 26, 1933, were: right arm, 230/110; left arm, 140/100; right leg, 120/98; left leg, 105/80. The abdomen and genitalia are negative. The neurological examination reveals a bilateral optic atrophy, primary in nature, with bilateral pyramidal signs associated with

skeletal deformities such as pes cavus and hammer toe. The conclusion is a heredodegenerative disease of the central nervous system, with cardiac abnormalities and associated hypertensive encephalopathy. Roentgenographic examination two days after admission (Fig. 3) revealed an enlarged cardia with a left ventricular preponderance, an absent aortic knob, and scalloping of the inferior margins of the ribs in their posterior portions. The patient became progressively worse and on May 7, 1935, his temperature rose to 104, respirations increased; he began coughing, and diagnosis of a bronchopneumonia was made. He failed to rally and died four days later.

The autopsy findings revealed a lobar pneumonia, subacute vegetative endocarditis, congenital anomaly of the heart (occlusion of the aortic lumen), hypertrophy and dilatation of the heart and emboli to the brain. The following is reported in detail: The pericardial sac is enlarged and occupies the entire lower portion of the left pleural cavity compressing the lower part of the lung. The fluid in the pericardial sac is normal. The heart weighs 750 gm.; epicardium is smooth. The myocardium of the left ventricle measures 2.5 cm. in thickness: the right ventricle is 0.75 cm. Section of the aortic valve shows it to be bicuspid, with a few fenestrations beneath its edge. The mouths of the coronaries show early atheromatous changes, with wrinkling of intima and a slight narrowing of the lumen. The ascending portion of the aorta appears normal. The right innominate artery is markedly dilated and shows early atheromatous changes at its site of origin. The left carotid artery is markedly dilated and enlarged. The left subclavian artery is small and atrophic in appearance. Just distal to the point of origin or the last-named vessel, the arch of the aorta is found to be completely occluded and does not allow the passage of even a small probe. The mouth of the subclavian artery is narrowed but patent. Distal to the occlusion of the aorta, there is noted in its posterior part, the origin of the second intercostal arteries. Both arteries are dilated and show hypertrophy and enlargement, the left being greater than the right. The thoracic and abdominal aorta is atrophic, measuring one centimeter. Circulation to the left arm came from a collateral circulation established between the internal mammary and long thoracic arteries. The pulmonic valve is normal. The left auricle is dilated and hypertrophied. The edge of the mitral valve is thickened, and a large amount of hemorrhagic cauliflower-like vegetation is noted along the margin of its leaflets. The chordæ tendinac and papillary muscles are hypertrophied. The tricuspid valve is normal. The myocardium is brown with irregular white fibrous patches. The foramen ovale is closed and the wall of the left ventricle bulges into the right ventricle.

We wish to thank Dr. Lynn J. Boyd, Director of Medicine, for his kind permission to report these cases.

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REFERENCES

(1) MECKEL, A.: Verschliessung der Aorta am vierten Brustwirbel. Arch. f. Anat. u. Physiol., p. 345, 1827.

(2) RAILSBACK, O. C., and DOCK, WILLIAM: Erosion of Ribs Due to Stenosis of Isthmus: (Coarctation) of Aorta. RADIOLOGY, **12**, 58–61, January, 1929.

(3) BONNET, L. M.: Sur la lesion dite stenose congenitale de l'orte. Rev. de Med., **23**, 108, 255, 335, 418, 481, 1903.

(4) BLACKFORD, L. M: Coarctation of Aorta. Arch. Int. Med., **41**, 702–735, May, 1928.

(5) HAMILTON, W. F., and ABBOTT, M. E.: Am. Heart Jour., **3**, 381–421, April, 1928.

(6) ULRICH, H. L.: Am. Heart Jour., **7**, 641–651, June, 1932.

(7) ABBOTT, M. E.: Coarctation of Aorta. Osler, Modern Med., **4**, 772, 1927.

(8) EVANS, W.: Congenital Stenosis (Coarctation), Atresia and Interruption of the Aortic Arch: Study of 28 Cases. Quart. Jour. Med., **2**, 1–31, January, 1933.

(9) LEWIS, T.: Material Relating to Coarctation of Aorta of Adult Type. Heart, **16**, 205–243, June, 1933.

(10) FRAY, W. W.: Roentgenologic Diagnosis of Coarctation of Aorta (Adult Type). Am. Jour. Roentgenol. and Rad. Ther., **24**, 349–362, October, 1930.

(11) FINESILVER, B.: Congenital Stenosis of Aorta: Cerebral Complications. Jour. Nerv. and Ment. Dis., **83**, 37–42, January, 1936.

THE EFFECT OF RADIATION APPLIED DIRECTLY TO THE BRAIN AND SPINAL CORD[1,2]

I. EXPERIMENTAL INVESTIGATIONS ON *MACACUS RHESUS* MONKEYS

By LEO M. DAVIDOFF, M.D., CORNELIUS G. DYKE, M.D., CHARLES A. ELSBERG, M.D., *and* ISIDORE M. TARLOV, M.D., *New York City*

THE effect of radiation applied directly to the central nervous system was studied experimentally as a basis for its clinical use in children and in adults with irremovable or only partially removable tumors of the brain. It is well known that some histologic types of tumors of the central nervous system respond to radiation applied through the overlying tissues, but even in the most radiosensitive growths—such as the medulloblastomas which occur in the midline of the posterior cranial fossa in children—one cannot speak of a cure by this method of therapy. Since there are obvious advantages in the elimination of the intervening bone and soft tissues between the source of radiation and the area to be irradiated, experiments on *Macacus rhesus* monkeys were undertaken in order to gain information regarding the dangers and limitations of the application of radiation directly to the brain and spinal cord through the open wound.

The effects of varying sized doses of roentgen rays applied directly to the brain and spinal cord of these animals are here reported in their clinical and histologic aspects. The study of the results obtained by this mode of therapy, in a series of patients with tumors of the central nervous system, will form the basis for a separate report.

LITERATURE

The literature on the effect of irradiation on the normal brain is meager. In a two-volume work on the "Biological Effects of Radiation," by Duggar, Warren was able to give a résumé of the articles on this subject, which had appeared up to 1933, in less than a single page. All of the experimental work was carried out in the intact animal, excepting in the case of Beier (1910) who made trephine openings in the skulls of rabbits, but closed the incision in the soft tissues before the head was exposed to radiation. Warren followed a similar procedure in experiments on dogs. Much of the work was carried out in immature animals and in many instances not only the head, but the entire animal, was irradiated.

MATERIAL AND METHODS

Our experimental studies were carried out on adult, average-sized *Macacus rhesus* monkeys. A total of 16 animals were used, divided into three groups. In one group (eight animals), the brain was irradiated; in another group (five animals), the cerebellum and medulla oblongata, and in a third group (three animals), the spinal cord. The individual monkeys in each group received different doses of irradiation, and most of the animals were permitted to live until spontaneous death occurred. At the present time (see Table I) ten animals have succumbed and six are still alive. A histologic study of the central nervous system and other organs of the animals that died forms the basis for the present paper.

The method of procedure was the following: The monkeys were anesthetized with an intraperitoneal injection of Dial (Ciba), 0.5 c.c. per kilogram of body weight, and the part of the nervous system to be irradiated was exposed under aseptic precautions. A soft tissue flap was made in the head, the bone removed with rongeurs, and the dura was opened widely. In the experiments on the spinal cord, the dura was left intact. The adjacent bony

[1] Supported by a grant from Child Neurology Research (Friedsam Foundation).

[2] Presented before Fifth International Congress of Radiology, at Chicago, Sept. 13–17, 1937.

and soft tissues were protected against the irradiation by three layers of heavy lead rubber. In no instance was there any evidence of epilation in the protected areas.

Fig. 1. Patchy demyelinization of brain, chiefly on the left side. Note adherence of dura to left cerebrum. Monkey received 5,400 r to the left cerebrum and died 148 days later. Weigert's myelin sheath stain; ×2.5.

The source of irradiation was a Westinghouse Quadrocondex constant-potential unit, in the first four animals, and a Waite and Bartlett shock-proof, oil-cooled unit for the remaining 12 animals. The physical factors employed were:

Kilovolts	200
Milliamperes	25
Target-skin distance	50 cm.
Portal	4 × 5 cm. (cerebrum and cerebellum)
	1 × 4 cm. (spinal cord)
Filtration	2 mm. Al and 0.5 mm. Cu
r per minute = 58	

The exceptions to the above mentioned factors were that in the four monkeys treated with the Quadrocondex unit, the milliamperage was eight, the r per minute, 20, and the filter 1 mm. Al and 0.5 mm. Cu. All doses were measured in air without back-scattering.

With this physical set-up, the monkeys received from 1,000 r to 5,000 r in a single dose, with the exception of three animals in which the brain was exposed twice, one week apart, and that received a total dose of 4,800, 5,400, and 7,200 r, respectively.

THE CLINICAL EFFECTS OF IRRADIATION AND THE HISTOLOGICAL CHANGES

1. *Radiation Applied to the Cerebrum*

Monkey No. 1.—This animal had received 5,400 r to the *left* cerebrum in two doses, one week apart. Four days after the second irradiation, a mild right hemiparesis developed, which persisted. The animal remained otherwise well for 130 days, then became apathetic, paralysis of the right limbs became more marked, and death occurred on the 148th day.

Autopsy: The skin on the *right* side of the head was epilated. The brain showed a false membrane over the left cerebral hemisphere at the operative site and this was adherent to the cerebrum. The left cerebral hemisphere seemed somewhat smaller and distinctly harder than normal, especially as compared to the right side.

There was no gross change in any other organ of the body, although the mesenteric glands were enlarged. Specimens of the scalp and of the muscles and bones of the head were preserved. The left eye was removed with the optic nerve and it was preserved, together with the pituitary body, thyroid, thymus, lungs, liver, spleen, pancreas, adrenals, kidneys, testicles, stomach, and part of the duodenum.

Aside from the presence of a number of enlarged mesenteric glands probably representing a tuberculous infection, no cause of death, except for the cerebral lesion, could be discovered.

After hardening in formaldehyde, the brain was sectioned. The cortex of the left cerebral hemisphere appeared thin, and the white matter softened and granular.

Microscopic: Left Hemisphere: The meninges were thickened and adherent to the cortex. The hemisphere contained a large cavity surrounded by gliosis. Moreover, the walls of the cavity presented numerous fat-filled phagocytes and Nissl's plump cells. There was considerable hypertrophy of the astrocytes with fragmentation of processes and disintegration of the cells. The usual stages in the transformation of microglia to com-

pound granular corpuscles were found. There were examples of acute swelling of oligodendroglia.

changes in the nerve cells, neuroglia, microglia, and in the blood vessels which were similar to those encountered on the

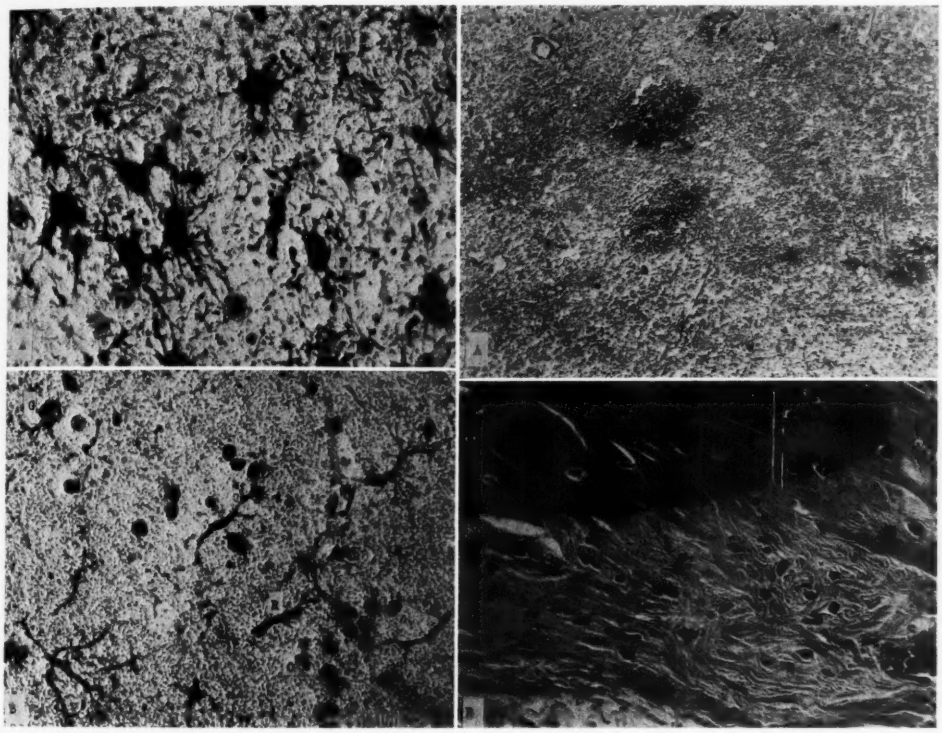

Fig. 2-*A* (*above, left*). Clasmatodendrosis (ameboid glia) of astrocytes in right cerebrum showing breaking up of expansions with formation of "filling bodies" (*F*). Monkey received 4,800 r to right cerebrum and died two weeks later. Cajal's gold chloride–mercuric chloride impregnation; ×750.

Fig. 2-*B* (*below, left*). Transformation of microglia into rod cells (*R*) and compound granular corpuscles (*G*) in right cerebrum. Note acute swelling of oligodendroglia (*O*). Same monkey as above. Rio-Hortega's silver carbonate impregnation; ×850.

Fig. 3-*A* (*above, right*). Hemorrhages in left cerebrum resulting from degeneration of blood vessel walls. Monkey received 7,200 r to left cerebrum and died ten days later. Hematoxylin and eosin; ×160.

Fig. 3-*B* (*below, right*). Ossification proceeding from bony trabeculæ of skull along dura mater. Note osteocytes bordering bone and dura. Monkey received 1,856 r to right cerebrum and died 322 days later. Hematoxylin and eosin; ×800.

The nerve cells showed intense degenerative changes characterized by vacuolization of cytoplasm, eccentricity of nuclei, rupture of cytoplasmic membrane, and disintegration or shrinkage of the entire cell body. There was no neuronophagia. The normal polarity of the ganglion cells was disturbed. The blood vessels showed a slight connective tissue-thickening and in a few instances hyaline changes.

The *right cerebral hemisphere* showed left side of the brain, but less marked. No cellular increase surrounded the cavitation in the right subcortical region.

Myelin sheath preparations through the coronal plane of the two hemispheres showed widespread, patchy demyelinization throughout the centrum semi-ovale and internal capsule, and, to a lesser extent, in the basal ganglia, including the pons. The changes were more marked on the left side of the brain (Fig. 1).

There was an area of massive necrosis

in the liver; other organs showed no abnormality.

Monkey No. 2.—This animal received 4,800 r in two doses of 2,400 r, one week apart, to the right cerebral hemisphere. Two days after the second irradiation, there was weakness of the left upper extremity, and on the fourth day, there was complete left hemiplegia. The animal died three days later.

Autopsy: The brain was bulging moderately through the defect in the bone. There was purulent material on the external surface of the dural flap. On smears, the pus contained many cocci.

Microscopic study: The ganglion cells of the brain, especially of the right cerebral hemisphere, showed well defined degenerative changes varying from vacuolization of cytoplasm and dissolution of Nissl's bodies, to complete disintegration of cells. Neuronophagia did not occur. There was disruption of the normal polarity of the ganglion cells. There was diffuse hypertrophy of astrocytes with regressive changes leading to the formation of enlarged cell bodies with short fragmented processes (Fig. 2-*A*). Early rod cell forms occurred and there was acute swelling of oligodendroglia (Fig. 2-*B*). There was swelling of the endothelial cells of the blood vessels with some thickening of the vessel walls. There were no areas of cavitation, and but slight demyelinization had occurred.

There were areas of necrosis in the liver affecting the interlobar zones, but no abnormality was noted in the other organs.

Monkey No. 3 received 7,200 r in two doses of 3,600 r each, to the left cerebral hemisphere. One week after the first irradiation, the animal appeared well, excepting for slight weakness of the right upper extremity. A second dose of 3,600 r was then given. On the following day, there was complete right hemiplegia and death occurred two days later.

Autopsy: The flap was bulging and there was considerable pus on the surface of the bulging brain where the convolutions appeared soft and necrotic. On smears, the pus contained some cocci.

Microscopic: Left Cerebral Hemisphere: There was marked disorganization of architecture in the gray and white matter, with cavitation and abscess formation extending into the meninges. Polymorphonuclear leukocytes, lymphocytes, and plasma cells occurred within the abscess, which lacked a limiting wall. There was no increase in the interstitial cells of the brain although hypertrophy of astrocytes with degenerative changes characteristic of clasmatodendrosis occurred. Evidence of transformation of microglia to rod cells and compound granular corpuscles was seen. Few examples of acute swelling of oligodendroglia were encountered. There were marked degenerative changes in the ganglion cells characterized by pulverization and disappearance of Nissl's substance, eccentricity of nuclei, and dissolution of cell membranes. There was practically no evidence of satellitosis or neuronophagia. There was some degeneration of blood vessel walls with small hemorrhages (Fig. 3-*A*).

Right Cerebral Hemisphere: There was an increase in the perivascular and perineuronal spaces with interstitial vacuolization affecting the gray and white matter. The astrocytes had undergone slight hypertrophy. The changes in the ganglion cells were similar to, but somewhat less marked than, those in the left cerebral hemisphere.

Microscopic study of other organs showed nothing abnormal.

Monkey No. 11.—This animal received 1,856 r to the right cerebral hemisphere. The animal was well for 188 days when it appeared to have a left homonymous hemianopsia. On the 249th day, it had definite weakness and contractures of the left extremities. The animal died on the 322nd day after irradiation.

Autopsy: There were adhesions of the dura in the region of the bony defect. The entire right hemisphere was yellowish-brown in color and rather soft. The left temporal lobe was affected to a lesser degree. There was a small subarachnoid

hemorrhage on the dorsal surface of the medulla oblongata.

After hardening, the brain was sectioned. On gross inspection, there was marked dilatation of the ventricles, especially on the left side, with softening which chiefly affected the white matter of the right hemisphere. In the softened areas there were several small hemorrhages.

Microscopic: The *right cerebrum* presented multiple cavitation, with widespread disruption of normal architecture, involving the white matter more than the gray. The cavities contained necrotic tissue and were surrounded by gliosis. Fat-filled phagocytes and Nissl's ameboid cells were present in the wall. Astrocytes showed widespread hypertrophy with formation of monster cells, some binucleated. Degenerative changes in astrocytes were most marked in the immediate region of the cavity. There was widespread acute swelling of oligodendroglia. Transitions from microglia to rod cells and compound granular corpuscles were easily found. Fat could be seen within few of these rod cells and abundantly within the compound granular cells. The latter cells frequently surrounded blood vessels and were within the perivascular spaces. Adjacent to such areas, one could see fat within the vessel lumen. The ganglion cells showed disturbance in their normal arrangement, with degenerative changes characterized by agglomeration of Nissl's granules, shrinkage of cells, and uniform blue staining of nuclei and cytoplasm in cresyl violet preparations. The blood vessels showed slight connective tissue-thickening with hyalinization of their walls and a few small hemorrhages. The meninges were thickened, and adherent to the brain. One could see evidence of ossification proceeding from bony trabeculæ along the fibrous tissue of the dura (Fig. 3-*B*).

The *left cerebrum* showed increase in perivascular and perineuronal spaces, with disorganization of gray and white matter and small cavitation surrounded by gliosis. Many Nissl's plump cells were seen in the vicinity of the rarefied zones, and there was some gliosis. There was marked subependymal rarefaction with disruption of the ependymal lining. Changes in oligodendroglia, microglia and astrocytes, ganglion cells, blood vessels and meninges were similar to those occurring in the opposite cerebrum, although less marked.

No changes were found microscopically, in the other organs.

Monkey No. 14 received 3,000 r to the right side of the cerebrum. After four and one-half months, the animal began to lose weight and to show an increasing left hemiparesis. The animal was in very poor condition one month later and was killed on the 172nd day after the irradiation.

Autopsy: There was a discharge of purulent material from behind the right ear which appeared to issue from a defect in the scalp and bone. The entire right petrous portion of the temporal bone appeared necrotic. Upon removal of the brain, it was found that the entire right temporal lobe had been destroyed by a necrotic process which appeared to be on the basis of an infection and which, so far as could be judged, was secondary to the destruction of the temporal bone. The remainder of the brain appeared edematous, but otherwise grossly normal.

Microscopic Examination: On section, there was definite demyelinization of the right, and, to a slight extent, of the left, cerebral hemisphere.

Right Cerebrum: The meninges over the hemisphere were thickened and adherent to the brain. The brain contained a large abscess which was connected with the meninges. There were many areas of rarefaction in the white matter. There was some hypertrophy of astrocytes (Fig. 4) and clasmatodendrosis in the vicinity of the tissue destruction. Numerous pyknotic ganglion cells were present. There was moderate connective tissue-thickening of the blood vessels.

The *left cerebrum* showed well-marked degenerative changes with small cavitation. Little, if any, tissue reaction surrounded this cavity.

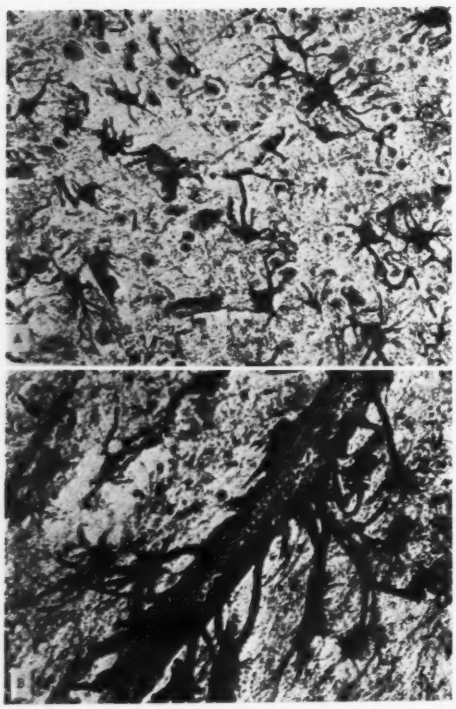

Fig. 4-*A* (*above*). Hypertrophy of astrocytes in right cerebrum with degenerative changes. Monkey received 3,000 r to right cerebrum, having been killed 172 days after irradiation. Cajal's gold chloride–mercuric chloride impregnation; ×725.
Fig. 4-*B* (*below*). Same as above; ×750

Microscopic study of other organs revealed no abnormality.

Monkey No. 15 received 4,000 r to the right cerebral hemisphere. Five days later there was slight left hemiparesis which did not increase until four months later. The animal lost flesh and became weak, and died 156 days after being irradiated.

Autopsy: There were adhesions between dura and brain in the operative area. The right cerebral hemisphere appeared somewhat shrunken.

Microscopic Examination: There was thickening of the meninges over the right cerebral hemisphere. The entire brain showed an increase of the perineuronal and perivascular spaces, with vacuolization and small subcortical cavitations which were surrounded by but little increase in cells (Fig. 5-*A*). There was fairly widespread dissolution of the Nissl's substance of the ganglion cells with pyknotic cells (Fig. 5-*B*), and but an occasional instance of neuronophagia. Hypertrophy of astrocytes with clasmatodendrosis and transformation of microglia to rod cells was noted. There was slight connective tissue-thickening of the blood vessels.

The degenerative changes in the left cerebral hemisphere and cerebellum, although well marked, were less advanced than those on the right. There were patchy areas of demyelinization in the centrum ovale, chiefly on the right side.

Other organs showed no abnormality.

Monkey No. 16.—This animal received 5,000 r to the right side of the brain. After five days there was a left hemiparesis. The paralysis increased gradually and became complete in two months. Death occurred about four months after irradiation.

Autopsy: Marked edema of the right orbital tissues and of the neck and throat with ulceration in the pharynx, including the right side of the mouth and tongue, was found.

There were adhesions of the dura to the brain in the operative area. The right side of the brain appeared smaller, and was firmer in consistency, than the left.

Microscopic Examination: On section, there were areas of demyelinization in the centrum semi-ovale, internal capsule and basal ganglia, especially on the right side. There were several large cavities in the right cerebral hemisphere which involved both gray and white matter, and were surrounded by gliosis (Fig. 5-*C*), the walls containing many fat-filled phagocytes and Nissl's plump cells. The ganglion cells were severely damaged, being vacuolated and staining poorly. The blood vessels had undergone moderate connective tissue-thickening with some hyaline degeneration, resulting in small hemorrhages. The changes in the left hemisphere were similar to those in the right but less marked. The cerebellum showed well-marked degenerative changes affecting many of the Purkinje cells and those of the cerebellar nuclei.

2. Radiation to the Cerebellum and Medulla

Monkey No. 9.—This animal received 4,000 r to the exposed cerebellum and remained well for about six months. Increasing cerebellar ataxia was then observed, followed by emaciation. The animal was moribund, and was killed on the 243rd day (eight months) after irradiation.

Autopsy: The cerebrum had a normal appearance, as did also the cerebellum excepting for meningeal adhesions. The medulla oblongata and upper cervical cord felt somewhat firm. There were no gross changes elsewhere.

Microscopic Examination: The cerebrum showed slight vacuolization of the white matter with some chromatolysis of ganglion cells. The cerebellum presented patchy areas of degeneration of nerve fibers in the white matter. Many of the Purkinje cells showed chromatolysis, which was more striking, however, in the brain stem. The brain stem and spinal cord were riddled with cavitations (Fig. 6-*A*) which were surrounded by slightly hypertrophied astrocytes. The destruction involved the white matter more than the gray, and involved equally myelin sheaths, axis cylinders, nerve and interstitial cells. There was slight connective tissue-thickening of blood vessels with few examples of proliferative changes in the cells of the endothelium and adventitia leading to narrowing of the vessel lumen. Hyaline degeneration of vessel walls occurred, in one instance resulting in hemorrhage in the pons. Vacuolization of many of the cells of the choroid plexus was present and more advanced degenerative changes in these cells were seen (Fig. 6-*B*).

Other organs, aside from the occurrence of pneumonia, showed no change.

Monkey No. 10 received 5,000 r to the cerebellum and remained well for about three months. The animal then developed disturbances of equilibration, and died about one month later, with complete paralysis of the lower extremities.

Autopsy: The cerebrum appeared normal, and the cerebellum somewhat soft.

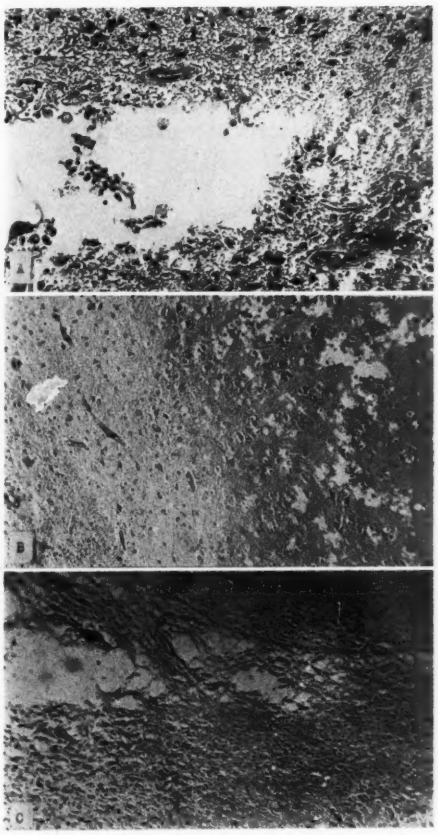

Fig. 5-*A* (*top*). Subcortical cavitation in left cerebrum surrounded by little cellular increase. Note Nissl's ameboid cells around cavity. Monkey received 4,000 r to right cerebrum and died 156 days later. Hematoxylin and eosin; ×310.

Fig. 5-*B* (*middle*). Pyknosis of ganglion cells of right cerebrum with increase in pericellular and perivascular spaces and vacuolization—slight thickening of blood vessels. Monkey received 4,000 r to right cerebrum and died 156 days later. Hematoxylin and eosin; ×150.

Fig. 5-*C* (*bottom*). Gliosis surrounding cavitation in right cerebrum. Monkey received 5,000 r to right cerebrum and died four months later. Hematoxylin and eosin; ×160.

The lower part of the medulla oblongata and the upper cervical cord felt abnormally hard.

Microscopic Examination: The striking abnormality was the occurrence of patches of demyelinization scattered throughout the white matter of cerebrum, cerebellum, pons, and spinal cord. Such changes were most marked in the brain stem and dorsal columns of the spinal cord (Fig. 7-*A*), in

which regions cavitation occurred. Nerve fibers remained relatively intact in some of the foci of demyelinization. In the more advanced zones of disintegration, astrocyte processes appeared fragmented and cell bodies swollen; changes suggestive of clasmatodendrosis. Acute swelling of oligodendroglia was encountered and transformation of microglia into rod cells and fat-laden compound granular corpuscles occurred. There was little, if any, cellular increase around the areas of destruction of brain tissue. The degenerative changes in the ganglion cells were marked. Blood vessels showed connective tissue-thickening, which was quite marked in the brain stem. There was marked degeneration of many of the cells of the choroid plexus of the fourth ventricle. Multiple splenic necroses (probably tuberculous) occurred.

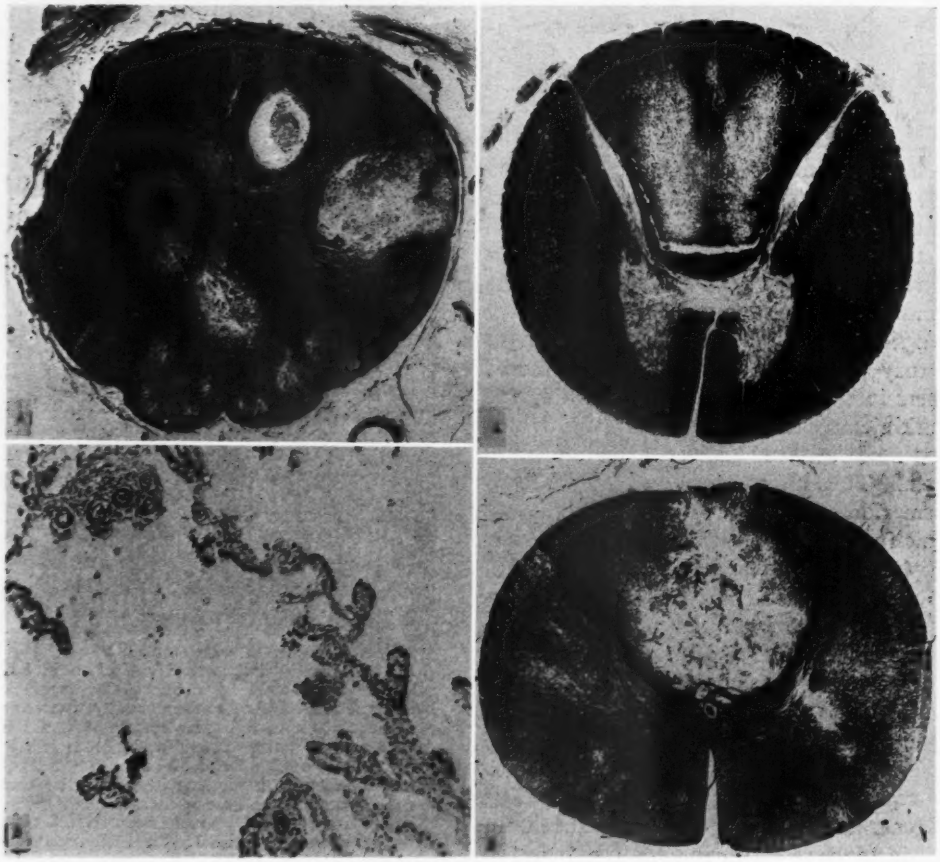

Fig. 6-*A* (*above, left*). Multiple cavitation of uppermost portion of spinal cord surrounded by no cellular increase. Monkey received 4,000 r to cerebellum and was killed after 243 days. Hematoxylin and eosin; ×15.

Fig. 6-*B* (*below, left*). Degenerative changes in choroid plexus of fourth ventricle. Monkey received 5,000 r to cerebellum and died one month later. Hematoxylin and eosin; × 275.

Fig. 7-*A* (*above, right*). Demyelinization of posterior columns of upper portion of spinal cord. Monkey received 5,000 r to cerebellum and died one month later. Weigert's myelin sheath stain; ×15.

Fig. 7-*B* (*below, right*). Cavitation of thoracic spinal cord without cellular increase. Monkey received 5,000 r to mid-thoracic spinal cord and died three days later. Hematoxylin and eosin; ×15.

3. Radiation to the Spinal Cord

Monkey No. 13 received 5,000 r to the mid-thoracic spinal cord, followed immediately by paralysis of the lower extremities. Death occurred after three days.

Autopsy: There was marked myelomalacia of the irradiated area.

Microscopic Examination: There was marked disintegration within the spinal cord with cavitation (Fig. 7-*B*) which involved both the gray matter and the white. Within the white matter, the myelin sheaths seemed to be more affected than the axis cylinders. There was practically no cellular reaction. Ganglion cells showed chromatolysis, and blood vessels had undergone but very slight connective tissue-thickening. The degenerative changes were most marked at the site of exposure.

Table I shows that of the 16 monkeys, ten died and six are still alive. All of the animals in which radiation was applied to the cerebrum in doses of from 1,856 to 7,200 r died. One monkey that received 1,000 r is living and well, almost two years after irradiation.

Of the five animals in which the cerebellum was irradiated, two died; one four months, and the other eight months, after the treatment. These monkeys received doses of 4,000 r and 5,000 r, respectively. Three animals (dosage 1,000, 2,400, and 3,000 r) are alive 22, 24, and 22 months, respectively, after irradiation.

In three animals the radiation was applied to the mid-thoracic spinal cord. One monkey (dosage 5,000 r) died after three days; the others are alive—one still well after about seven months (1,000 r), the other has had a paraplegia for 12 months, but is living at the present time, 20 months after receiving 4,000 r.

Of the ten animals that died, two (Nos. 2 and 3) died after from three to five days, from a wound infection, but both of these animals (dosage 4,800 r and 7,200 r) had a hemiparesis immediately after irradiation. In a third animal (No. 10), that received 5,000 r to the cerebellum and that lived for 121 days, death may have been due in part to visceral tuberculosis. In seven animals, death was due directly to the irradiation. Five of these died in 135 to 322 days (four and one-half to 11 months) after irradiation of the cerebrum, one 243 days (eight months) after irradiation of the cerebellum, and one three days after the spinal cord had been irradiated (dosage 5,000 r).

The main clinical symptoms presented by the animals in which a cerebral hemisphere was exposed to the roentgen rays, consisted of hemiparesis, which usually increased up to death. The animals in which the cerebellum was irradiated, developed ataxia after from three to five months, and one in which the spinal cord was exposed to the x-rays had a paraplegia immediately after irradiation.

Grossly, the predominant changes in the nervous system consisted of atrophy or softening of the irradiated hemisphere with adhesions between the brain and meninges. In two animals, there were ulcerative processes in the soft or bony tissue of the head or neck. In the animal in which the spinal cord was irradiated, there was a marked myelomalacia.

Microscopically, the effect of roentgen radiation proved to be primarily upon the parenchyma of the brain, rather than upon the blood vessels. Connective tissue-thickening of blood vessels did occur, but it was not sufficiently marked to account for the severe parenchymatous degeneration. In four cases, degeneration of the walls of blood vessels, with hemorrhage, occurred.

Chromatolysis of ganglion cells leading in some instances to complete disintegration without satellitosis or neuronophagia occurred. There was hypertrophy of astrocytes, frequently with gliosis around cavitation. Degeneration of astrocytes forming the ameboid glia of Alzheimer or the changes seen in clasmatodendrosis of Cajal occurred. There were numerous examples of fragmentation and disappearance of processes of oligodendroglia with distention of cell body by clear fluid,

TABLE I.—SUMMARY OF CLINICAL AND ANATOMICAL EFFECTS OF RADIATION TO THE CENTRAL NERVOUS SYSTEM IN *MACACUS RHESUS* MONKEYS

(Up to April 1, 1938)

Monkey No.	r	Immediate Effects	Later Effects	Outcome: Still Living	Outcome: Died	Histologic Changes at Necropsy
			Cerebrum			
1 Left side	1,800* + 3,600 = 5,400	Hemiparesis (right)	Increased paralysis after 4 mos.	.....	After 148 da.	(1) Cavitation of cerebral hemispheres surrounded by gliosis. (2) Widespread chromatolysis. (3) Disturbance in polarity of nerve cells in cortical laminæ. (4) Increase in pericellular and perivascular spaces with vacuolization of white matter. (5) Scattered demyelinization. (6) Degenerative changes in neuroglia and ependyma. (7) Formation of compound granular cells. (8) Slight connective tissue thickening of blood vessels with some hyalinization of walls.
2 Right side	2,400* + 2,400 = 4,800	Hemiparesis (left)	Infected wound	.....	After 14 da.	Changes similar to those in Monkey No. 1 without cavitation and otherwise much less marked.
3 Left side	3,600* + 3,600 = 7,200	Hemiparesis (right)	Infected wound	.....	After 10 da.	Intense degenerative changes as in Monkey No. 1 with (1) Abscess formation; (2) Degeneration of blood vessel walls resulting in small hemorrhages, and (3) Chromatolysis of ganglion cells of opposite cerebral hemisphere, more marked than in Monkey No. 1.
7 Left side	1,000	None	None	Well 1 yr. 311 da.	.....	
11 Right side	1,856	None	Left hemianopia and left hemiparesis after 6 mos.	.....	After 322 da.	Changes similar to those in Monkey No. 1 although (1) Degenerative changes were less marked, and (2) Small hemorrhages resulted from hyaline degeneration of blood vessels.
14 Right side	3,000	None	Increasing left hemiparesis after $4^1/_2$ mos.	.....	After 172 da.	Changes similar to those in Monkey No. 1 although (1) Abscess formation had occurred, and (2) No cellular increase surrounded cavitation in hemisphere opposite to the exposed one.
15 Right side	4,000	Slight hemiparesis (left)	Progressive debility and paralysis after 4 mos.	.....	After 156 da.	Changes similar to those in Monkey No. 1 although (1) Degenerative changes were less marked, and (2) Very little cellular increase surrounded cavitation.
16 Right side	5,000	Hemiparesis (left)	Paralysis complete after 2 mos.	.....	After 135 da.	Intense degenerative changes as in monkey No. 1 with (1) Small hemorrhages resulting from hyaline degeneration of blood vessels.

			Cerebellum and Medulla			
4	2,400	None	None	Well 2 yr. 15 da.	.....	
6	1,000	None	None	1 yr. 311 da. Weakness both lower extremities for about 1 yr.	.....	
8	3,000	None	None	Well 1 yr. 294 da.	.....	
9	4,000	None	Cerebellar ataxia after 5 mos.	.....	After 243 da.	Changes similar to those in Monkey No. 1 except that (1) Cavitation involved brain stem and upper portion of spinal cord; (2) No cellular increase surrounded cavitation; (3) Proliferative changes of endothelial and adventitial cells occurred; (4) Small hemorrhages in pons resulted from hyaline degeneration of blood vessels, and (5) Degenerative changes in cells of the choroid plexus occurred.
10	5,000	None	Cerebellar ataxia after 3 mos.	.....	After 121 da.	Changes similar to those in Monkey No. 9 except that (1) Proliferative changes of blood vessels did not occur; (2) Hemorrhages were not present; (3) Chromatolysis of cells of brain stem was more marked, and (4) Degenerative changes of choroid plexus were more marked.
			Spinal Cord (Mid-thoracic)			
5	1,000	None	None	Well 205 da.	.....	
12	4,000	None	None	1 yr. 261 da. Paraplegia lower extremities for 1 yr.	.....	
13	5,000	Paraplegia	Rapid deterioration	.....	After 3 da.	(1) Multiple cavitations. (2) No cellular increase around cavitation. (3) Myelin sheaths more affected than axis cylinders in degeneration. (4) Chromatolysis.

Above changes in all cases were most intense at site of exposure to x-rays.

* The first three animals received divided doses one week apart.

characteristic of the acute swelling of oligodendroglia described by Penfield and Cone. Swelling of microglia, with fragmentation of cell processes forming rod cells, occurred. These changes in nerve cells, astrocytes, oligodendroglia, and microglia were concomitant findings. Adjacent to areas of necrosis of tissue, various stages in the transition from microglia and rod cells to fat-laden compound granular corpuscles (*Gitterzellen*), which frequently filled the perivascular spaces, were found. Scharlach R preparations revealed fat within the lumen of the blood vessel in some instances, with rod cells and microglia a short distance from the vessel wall, suggesting transfer of the phagocytized material into the vessel with resumption of the normal microglia form as suggested by Penfield (1925). All of the material showed an increase in perivascular and perineuronal spaces, with interstitial vacuolization affecting the white matter more than the gray. Frequently, patchy areas of demyelinization, which were not necessarily in relation to blood vessels, were found.

A later stage in degeneration seemed to be represented by cavitation which, in the cerebrum, was usually surrounded by gliosis and involved the white matter more than the gray. Numerous fat-filled phagocytes and Nissl's plump cells often occupied the walls of these cavities.

It is of interest that little or no evidence of satellitosis and neuronophagia followed ganglion cell degeneration. This fact, together with the usual absence of gliosis around cavitations in the brain stem or spinal cord, is rather suggestive of a damaging effect of irradiation upon the ability of neuroglia to react in its usual manner. However, gliosis did occur in many instances around cavitations within the cerebrum, the intensity of the gliosis appearing to vary directly with the dosage of x-ray and, probably to a greater extent, with the survival period of the animal.

SUMMARY

The effects of large single doses of roentgen rays, directly upon the brain and spinal cord of monkeys, were very marked, and the rapidity with which the clinical symptoms occurred was proportional to the dosage. A dose of 4,000 r or more to a cerebral hemisphere was followed almost immediately by a more or less well-marked paralysis of the contralateral limbs. After a dosage of approximately 2,000 to 3,000 r, the animals developed a hemiparesis after several months.

None of the animals in which the cerebellum was irradiated, developed any immediate symptoms, but in two of them (dosage 4,000 r and 5,000 r) cerebellar disturbances appeared after from three to five months.

Of the three animals in which the midthoracic spinal cord was exposed to the radiation, one developed immediate paraplegia (dosage 5,000 r), and another (dosage 4,000 r) developed a paraplegia after five and one-half months.

These results indicate that the small brain of the *Macacus rhesus* monkey will tolerate massive single doses of x-ray applied directly through the open wound in doses of less than approximately 2,000 r to the cerebrum, and less than 4,000 r to the cerebellum and spinal cord, without causing death of the animal. However, the monkeys that are still alive after about two years, may in the future succumb to the effects of irradiation. It is of particular interest that the disabilities these monkeys presented frequently came on as a late effect following irradiation, and that they were progressive.

In all the animals which died, there were well-marked changes in the central nervous system. When one cerebral hemisphere was irradiated, both the homolateral and the contralateral hemispheres were involved—the latter much less than the former. The changes in the cerebellum following irradiation to this region were similar to those in the cerebrum and lesions were found also in the medulla and cervical spinal cord. When large doses of radiation were applied to the cerebrum, chromatolysis of ganglion cells of the cerebellum

occurred; similarly when the cerebellum was thus irradiated, degeneration of ganglion cells of the cerebrum was found. The effects of massive doses of roentgen rays were especially marked in the glia and nerve tissues, and, surprising as it may seem, the changes in the blood vessels were slight in degree. The irradiation produced mainly a parenchymatous degeneration, both nerve and glia cells being profoundly affected, the axis cylinders sometimes appearing to be less severely involved than the myelin sheaths.

The two factors which seemed to play a part in governing the intensity of the histological changes were the dosage of x-ray and, to a less extent, the time interval between irradiation and autopsy. It seemed, both on clinical and histological grounds, that the destructive changes were to some extent progressive, although the period of time during which such progressive changes may occur has not been determined.

BIBLIOGRAPHY

(1) BAGG, H. J.: The Action of Buried Tubes of Radium Emanation upon Normal and Neoplastic Tissues. Am. Jour. Roentgenol., **7,** 536–544, 1920.

(2) CAIRNS, H., and FULTON, J. F.: Experimental Observations on the Action of Radon on the Spinal Cord. Lancet, **2,** 16, July 5, 1930.

(3) DEMEL, R.: Tierversuche mit der Röntgenbestrahlung des Cerebrums. Strahlentherapie, **22,** 333–336, 1926.

(4) EDWARDS, D. J., and BAGG, H. J.: Lesions of the Corpus Striatum by Radium Emanation and the Accompanying Structural and Functional Changes. Am. Jour. Physiol., **65,** 162–173, June, 1923.

(5) LYMAN, R. S., KUPALOV, P. S., and SCHOLZ, W.: Effect of Roentgen Rays on the Central Nervous System. Arch. Neurol. and Psychiat., **29,** 56–87, January, 1933.

(6) MARBURG, O., and SGALITZER, M.: Die Röntgenbehandlung der Nervenkrankheiten. Strahlentherapie, **37** (Sonderband 15), 1–20, 1930.

(7) PENDERGRASS, E. P., HAYMAN, J. M., JR., HOUSER, K. M., and RAMBO, V. C.: The Effect of Radium on the Normal Tissues of the Brain and Spinal Cord of Dogs, and its Therapeutic Application. Am. Jour. Roentgenol., **9,** 553–569, September, 1922.

(8) RACHMANOW, A.: Zur Frage über Wirkung der Röntgenstrahlen auf das zentral Nervensystem. Strahlentherapie, **23,** 318–325, 1926.

(9) WARREN, S. L.: Biological Effects of Radiation. **1,** 507. Benjamin M. Duggar, Editor. McGraw-Hill Book Co., New York, 1936.

(10) ZIMMERN, A., and CHAVANY, J. A.: Die Radiosensibilität des Nervengewebes. Strahlentherapie, **41,** 482–495, 1931.

CHARACTERISTICS OF X-RAYS

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A. *Production of X-rays*

1. X-ray tube: An envelope of glass containing a filament, target, and an extremely high vacuum.
   (*a*) Target
      (1) High melting point—in order to withstand higher temperatures—hence a higher capacity in production of x-rays.
      (2) High atomic weight—to secure a better output of radiation, or characteristic x-rays of a better quality.
      (3) Low vapor pressure—to keep volatilization at a minimum, so as to avoid metallic deposit on the walls of the x-ray tube.
      (4) Good conductor of heat—enhanced by embedding a target in a copper sleeve and also by cooling same with air, water, and oil.
2. Change of kinetic energy of electrons to radiant energy depends upon:
   (*a*) Attraction of electrons to the target
      (1) Electrons carry a negative charge—hence the target must carry a positive charge compared to the electron because mutual attraction between unlike charges causes the electron to move to the target.
      (2) As the difference in charge or potential increases, more energy will be imparted to the electron emerging from the filament of the x-ray tube.
      (3) The electron is suddenly stopped at the face of the target and about one-half of 1 per cent of the kinetic energy goes into x-rays, while about 99.5 per cent goes into heat.
      (4) In the sudden stopping of the fast moving electron, *general x-rays* are produced —since the electron has its own magnetic field, the magnetic field tends to go on, or is bent when the electron is suddenly stopped, with the result that an electromagnetic wave of radiant energy emerges from the target.
      (5) Characteristic x-rays: When the electrons from the filament of the x-ray tube attain sufficient speed, the atomic structure of the target atoms are penetrated.
         (*a*) When the filament electron enters the atomic structure, some of the atomic structure, some of the atomic orbital electrons are displaced. As the position or energy level of the displaced orbital electrons is reoccupied by another electron, the energy required to displace the electron is returned in the form of radiant energy.
         (*b*) As the atomic weight of the target is increased, a higher voltage is required to give the filament electrons sufficient

energy to enter the more complicated atomic structure.

(*c*) This radiant energy is called "characteristic" or "fluorescent" because it is characteristic in wave lengths for any particular emittor.

(*d*) Characteristic x-rays are classified as K, L, M, N, etc., depending upon whether an electron is displaced from the innermost electronic orbit known as K, or outer orbits known as L, M, etc. Hence the shortest band of wave lengths arises because an electron is displaced from the K orbit, a band of longer wave lengths from L orbit, etc.

(6) General x-rays, therefore, comprise a heterogeneous group of wave lengths running from the longest wave length capable of penetrating the glass bowl of the x-ray tube and the shortest wave length, which is a function of the maximum or peak voltage applied to the target.

(7) Characteristic x-rays comprise a series of more or less homogeneous bands of x-ray wave lengths arising from the K electronic orbit of the atom, and another more homogeneous band arising from the L electronic orbit, etc. The different bands of characteristic wave lengths occupy definite positions in the x-ray spectrum depending upon the atomic weight of the x-ray target.

(8) The x-ray spectrum represents a composite picture of characteristic radiation superimposed on general x-rays.

B. *Properties of X-rays*

1. X-rays are invisible and transmitted through space in a similar manner to light.
2. Travel in straight lines.
3. Can be reflected and refracted from crystals.
4. Speed of light and x-rays is 186,000 miles per second.
5. Produced by impact of electrons on matter.
6. Ionizes gases.
7. Produces fluorescence and phosphorescence.
8. Produces chemical changes.
9. Biological changes in tissue by the process of ionization of the cell, causing a chemical change followed by biological changes.

C. *X-ray Spectrum:* A heterogeneous beam of x-ray wave lengths can be separated or diffracted by passing a narrow beam of x-rays through a rock salt or calcite crystal. According to the angle at which the primary beam enters the crystal, different wave lengths can be diffracted into an ionization chamber or onto a photographic film.

1. The regular arrangement of atoms in rock salt and calcite crystals diffract the x-ray wave lengths, giving the same results as are obtained by a line grating in diffracting light rays.
2. If an ionization chamber is used to measure the intensity of different wave lengths, a curve can be plotted to represent the x-ray spectrum with wave lengths in Ångstrom units as abscissa and corresponding intensities as ordinate (one Ångstrom unit equals 1.0×10^{-8} cm., or 0.000.000.01 cm.).
3. The maximum wave length is the longest wave length that can penetrate the glass of the x-ray tube.
4. The minimum wave length is the shortest wave length that is pro-

duced by a given peak voltage. Formula—

Minimum wave length in Ångstrom units $= \frac{12{,}354}{\text{peak voltage}}$

D. *The Factors Governing the Quality of X-rays*
   1. Target material: The characteristic x-ray wave lengths vary with the atomic weight. General x-ray wave lengths are the same for any material.
   2. Voltage: The minimum wave length decreases as the voltage increases.
   3. Filter: A filter removes a percentage of all wave lengths, the percentage of the minimum wave length being least and the percentage gradually increasing until a 100 per cent is absorbed. The quality of a filtered beam of x-rays is more homogeneous in short wave lengths.

E. *The Factors Governing the Quantity of X-rays as Measured in Air*
   1. The voltage: As the voltage is increased, a greater number of all wave lengths is produced, therefore increasing the intensity. The filament electrons are not stopped at the first impact, but as they penetrate into the target, x-rays of different wave lengths are produced until the electron is totally absorbed.
   2. Milliamperage: As more electrons are produced by an increase in filament current, a greater milliamperage results with an increase in intensity.
   3. Filter: Since the filter absorbs radiation passing through, the intensity is altered.
   4. Distance: The intensity varies approximately as the inverse square of the distance from the target. With the oil-immersed x-ray tubes, the inverse square law cannot be applied when measuring the intensity for very short skin-target distances, due to the scattering of x-rays in the oil.

F. *The Action of Filters*
   1. A very large percentage of the absorption of x-rays by low atomic weight substances is due to scattering of the radiation. The loss of energy by scattering results in lengthening of the wave lengths. Low atomic weight substances as aluminum, carbon, etc., are not good filters for high voltage radiation.
   2. Higher atomic weight filters function in two ways in changing the beam of radiation; by the process of scattering, and by the production of characteristic or fluorescent radiation in the filter. Since the production of characteristic radiation is a function of the atomic weight, the x-ray spectrum of filtered radiation indicates that for 200 kv. radiation, copper and a composite filter of tin, copper and aluminum give the best resultant beam.
   3. Copper is usually used for high voltage (200 kv.) radiation. A composite filter of 0.4 mm. tin + 0.2 mm. copper and 0.5 mm. aluminum is often substituted for 2.0 mm. copper + 0.5 mm. aluminum. The composite filter gives approximately the same quality of radiation as 2.0 mm. Cu, but allows from 15 to 20 per cent more radiation to pass through. A composite filter of lead + tin + copper + aluminum is often used for supervoltage therapy. The sequence of the different elements with varying atomic weights are necessary to remove characteristic radiation of the preceding filter. The aluminum is placed between the copper filter and the patient to remove the soft characteristic radiation from copper, and for the same reason, the copper is placed beneath the tin and the aluminum next to the patient.

G. *The Theory of Radiant Energy*
   1. The electromagnetic wave theory of x-rays was verified following the prediction of Professor Laue, in 1912.

that the regular arrangement of atoms in crystals as rock salt and calcite should diffract x-rays as light wave lengths are diffracted by a ruled grating. Friedrich and Knipping experimentally obtained an x-ray spectrum.

2. Following the discovery by Compton that a large percentage of scattered x-rays leave the scattering medium with a longer wave length than the primary beam, other experimental evidence made it difficult to explain all the facts by the electromagnetic continuous wave theory. If the electromagnetic wave can be visualized as being made up of units or chunks of energy called quanta, it would be possible to explain the discrepancies between experimental findings and the electromagnetic wave theory.

H. *Scattering of X-rays*

1. X-rays scatter very much as light scatters in a fog. The absorption of x-rays is almost entirely due to scattering in low atomic weight substances.
2. Quanta of x-ray energy is $h\nu$, h being Planck's constant 6.55×10^{-27} erg seconds and ν the frequency. The frequency (ν) times the wave length (λ) equals the speed of x-rays or light (c). It is readily seen that the quantum of energy of short wave length radiation has a higher frequency and a higher energy quantum than one of long wave length and low frequency.
3. As a quantum of energy strikes an atom, a recoil electron is ejected, and at the same time the quantum is deflected or scattered with a loss of energy. As Planck's constant cannot change, the frequency ν is reduced, with a resultant longer wave length, since the product of frequency and wave length equals the speed of x-rays, a constant.
4. The same quantum continues to scatter, the frequency being gradually reduced and corresponding wave length increased, until the quantum either emerges from the filter or comes in contact with an atom in such a manner as to be totally absorbed, at which time a photo-electron is ejected. The photo-electron leaves the atom with considerably more energy than the recoil electron. The photo-electron will travel farther in the tissue and produce more secondary ionization than the recoil electron.
5. The energy that a quantum loses in scattering is a function of the scattering angle. A quantum scattered back on itself will lose the maximum energy, a quantum scattered at right-angles will lose less energy, and a quantum can strike an atom and not give up any energy. If this happens, the wave length remains unchanged.

I. *Ionization:* The production of ions in a gas by x-rays, neutrons, radium rays, etc., which renders the gas conductive only while the source is present or active.

1. Since the composition of all atoms is an aggregation of electrical charges with a positive nucleus surrounded by sufficient number of electrons in motion to counteract the excess positive charge on the nucleus, the result is that all evidence of a charge is neutralized. X-rays, neutrons, radium rays, and other forces passing through a gas remove one or more electrons from a gas atom. This leaves the atom positively charged. These charges can be collected and the rate of ionization evaluated.
2. Because the conductivity of the gas continues only while x-rays are present, it is possible to measure the intensity of x-rays by measuring the conductivity of the gas which is a function of the rate of producing ions in the air.
3. The rate of ionization will change with the concentration of the number of atoms in a given volume of

gas, since all of the atoms in the path of the x-rays are not ionized. The concentration of atoms in a volume of gas will vary with the pressure and temperature, which means a variation in the conductivity of the gas.

J. *Measurement of the Quantity of X-rays in Roentgens*

1. Photographic Method: The rate of blackening of a photographic film is not the same when the wave lengths change; the same holds true for penetrometers or wedges of different filter thickness.
2. Chemical Method: Change in the color of certain dyes, as methylene blue—not in general use. Also the change in resistance of a selenium cell: the selenium cell becomes fatigued under action of x-rays which renders it inaccurate.
3. Fluorescence Method: Certain crystals fluoresce under the influence of x-rays, but there is no accurate method gauging the changes in fluorescence.
4. Biological Method: Erythema—qualitative and difficult to gauge degree of erythema accurately. Also varies with quality of radiation, and the texture of the skin.
5. Effect on *Drosophila* Eggs: Wood and Packard, and others, have carried out experiments in measuring the intensities of x-rays. This method has developed into more of a laboratory procedure.
6. The Thermal Method: This method could be used, but there is so little heat generated that it is almost impossible to measure it with the most sensitive instruments, and it would be still more complicated to measure small differences in x-ray intensities.
7. Ionization Method: This method has stood the test of time and has been adopted, with certain limitations, internationally as *the method* giving the greatest accuracy and the one most practical to use to standardize individual installations.
   (*a*) At the Bureau of Standards, and a few other laboratories, an air ionization chamber is maintained.
   (*b*) A thimble ionization chamber is compared directly with the air ionization chamber, and any wall effect is compensated for by direct comparison.

K. *Definition of the Roentgen:* "The quantity of radiation which, when the secondary electrons are fully utilized and the wall effect of the chamber is avoided, produces in 1 c.c. of atmospheric air at 0 ° Centigrade and 76 cm. of mercury pressure, such a degree of conductivity that one electrostatic unit of charge is measured at saturation current."

1. Secondary Electrons: X-rays passing through the gas between the plates of the ionization chamber strike a certain percentage of the atoms in their path and cause electrons to be ejected. The separated charges are called ions. The separated ions attracted to their respective plates of the ionization chamber collide with atoms and produce secondary ionization, or secondary electrons. The plates of the ionization chamber must be far enough apart to include all possible secondary electrons in order to measure the true ionization current.
2. To have the x-rays strike the walls of the ionization chamber would produce scattering and complicate the measurements, so the beam of x-rays is sent through diaphragms and the scattering eliminated.
3. Since the number of atoms in 1 c.c. of air varies with the atmospheric pressure and temperature, the roentgen must be that conductivity of air for some definite number of atoms in 1 c.c. Standard conditions have been chosen. When measuring x-rays at room temperature and at different barometric pressures, corrections must be made.

4. Saturated ionization current is that ionization current obtained when the voltage on the plates of the ionization chamber is such that all of the separated electrons will be attracted to the plates of the ionization chamber before they have a chance to recombine. If the force from the voltage on the plate is not as great as the force of attraction from the nucleus of the atom for the electron, some of the electrons will not reach the plates of the ionization chamber and the conductivity will be reduced.

L. *Measurement of Quality of Radiation:* The half value layer in copper, aluminum, etc.

1. A practical method of determining the half value layer is to measure the intensity through varying thicknesses of copper filter for deep therapy radiation and plot an absorption curve with filter thicknesses as abscissa and intensity in roentgens as ordinate. Note the intensity for 0.5 mm. Cu, reduce the intensity to half and find where a line drawn parallel to the abscissa passing through half of the intensity intersects the absorption curve. Draw a line parallel with the ordinate from the point of intersection to abscissa and note the corresponding millimeters of copper to give this intensity. The millimeters of copper to give half the intensity minus 0.5 mm. Cu represents the half value layer for radiation filtered by 0.5 mm. Cu. In the same manner the half value layer for radiation filtered by 1 and 2 mm. of copper can be obtained.
2. For 200 kv. radiation, copper is usually used to determine the half value layer; for superficial and skin therapy radiation, aluminum is probably better, due to the inability to get and use thin copper.
3. Effective Wave Length: The quality of radiation can be expressed in terms of that wave length of monochromatic radiation which will be absorbed in the same manner as the heterogeneous beam of wave lengths under consideration, both having the same half value layer. Curves by Duane, Mayneord, those in "Science of Radiology," and elsewhere show the relationship between effective wave length and half value layer, or some other intensity relationships between varying filters and wave lengths. The effective wave length can be obtained only from some previously constructed curve with wave lengths plotted against corresponding half value layers in copper, aluminum, or other material, or some designated filters.

M. *Scattering of X-rays by the Tissue*

1. A percentage of x-rays scatter back to the surface of a phantom or to the skin of a patient.
2. The percentage of back-scattering varies with the size of the field. In a small field there will be less back-scattered x-rays because the x-ray beam is reduced and because there is not as much tissue from which to scatter as occurs in a large field.
3. The percentage varies considerably from the center of the field of radiation to the periphery.
4. The percentages of the primary beam scattering back to the surface for approximately the same quality of x-rays and size of field differ considerably from one investigator to another due to the type of ionization chamber used in measuring back-scattered radiation. The percentage difference for different square centimeter fields is quite similar among different investigators.
5. Back-scattered measurements vary with the quality of radiation. The percentage of back-scattered radiation is less with supervoltage radiation heavily filtered than with deep therapy.
6. Scattering beneath the surface of a phantom or skin:

(*a*) With a large port of entry, there

is a greater depth dose than with a small field for the same reason as given for back-scattering; there are less x-rays to scatter.

(*b*) As the x-rays scatter down into the tissue, the quality of the radiation changes. The effective wave length and half value layer changes, showing that the wave lengths are gradually becoming longer due to the quanta of x-rays losing energy by scattering. Failla and Quimby measured the half value layer on the surface of a phantom, and then at ten centimeters depth and found a reduction of the half value layer at ten centimeters.

(*c*) In treating patients with x-rays, it is necessary to recognize that there is less radiation reaching a given depth as the port of entry is reduced.

(*d*) It is helpful to determine the number of roentgens that can be safely given over fields of various sizes, remembering that the biological factor for small fields is a greater factor than the variation in back-scattering or the reduction in the depth dose.

N. *Varying the Depth Dose*

1. Varying the Filtration: Increased filtration up to a certain point will give a better depth dose.
2. Varying the Voltage: Increased voltage will give a better depth dose.
3. Varying the Skin-target Distance: Keeping all factors constant such as the size of field, filter, and voltage, the depth dose can be increased by increasing the skin-target distance. The increase can be computed by applying the inverse square law. If a 50-cm. skin-target distance is used and the loss of radiation at 10 cm. depth is computed, $(50/60)^2$ equals 69.5 per cent. If a 70-cm. skin-target distance is used, the loss of radiation at 10 cm. depth is computed, $(70/80)^2$ equals 76.5 per cent. Take a depth intensity measurement at a depth of 10 cm. in tissue for a 50-cm. skin-target distance, and a given sized field to be 40 per cent. Since 40 per cent depth dose is based on 100 per cent at the surface, to find the percentage difference between the loss of radiation by changing the skin-target distance, it is necessary to divide 76.5 per cent by 69.5 per cent which equals 110 per cent. Forty per cent multiplied by 110 per cent equals 44 per cent depth dose for 70 cm. S.T.D.

O. *Depth Intensity Curves* (Called Iso-dose Curves)

1. Represent the percentage of radiation reaching various depths in the tissue compared to 100 per cent on the surface.
2. Loss of radiation as it penetrates the tissue—
   (*a*) The radiation intensity is reduced due to the divergence of the x-ray beam, and can be computed by the inverse square law.
   (*b*) The radiation intensity is reduced by the tissue totally absorbing some of the x-ray quanta.
3. There is a gain in the percentage of radiation intensity reaching various depths in the tissue due to—
   (*a*) Scattering of radiation passing through the tissue increases the percentage of radiation reaching a depth.
   (*b*) Percentage of radiation reaching a given depth in the tissue varies with the size of field because in reducing the size of the beam of radiation there are less x-rays to scatter.
4. The scattering back and forth of radiation that passes through and reaches a given depth in the tissue helps to offset the loss of radiation caused by divergence and total absorption of the rays.

5. Practical application of depth intensity charts—
   (*a*) Helpful in deciding upon the number and location of fields in attempting to deliver a predetermined tumor dose.
   (*b*) Depth intensity charts are compared to anatomical cross-sections enlarged to the size of the patient, passing through the part of the patient to be treated. The tumor area can be outlined. The percentage of radiation reaching the tumor area can be compared to the radiation reaching each skin area.
   (*c*) Helpful in determining the percentage of exit dose which must be taken into consideration in totalling the radiation on each skin area.

An attempt has been made to give an outline that will enable those taking the *Course in the Physics of Radiology* to do some studying. A bibliography of physics books dealing with radiology and publications on various physical principles is given so as to enable one to carry on an organized method of study. A study of the Outline alone is not sufficient to acquaint one fully with the principles involved.

It is evident that in attempting to cover the foregoing subjects, it will be necessary to move rather rapidly. Thus, in order to obtain the most from such a course of lectures, it is necessary to have the undivided attention of those attending. The Outline eliminates the necessity of taking notes, since each one attending will receive a copy of the Outline.

BIBLIOGRAPHY

1. Arneson, A. N., and Quimby, Edith H.: The Distribution of Roentgen Radiation within the Average Female Pelvis for Different Physical Factors of Irradiation. Radiology, **25,** 182–197, August, 1935.
2. Chalmers, T. A.: A New Instrument for Measurement of Ionizing Radiation. British Jour. Radiol., **7,** 755–763, December, 1934.
3. Compton, Arthur H.: The Scattering of X-rays. Radiology, **3,** 479–485, December, 1924.
4. Idem: X-rays and Electrons. D. Van Nostrand Co., New York.
5. Compton, Arthur H., and Allison, Samuel K.: X-rays in Theory and Experiment. D. Van Nostrand Co., New York.
6. Coolidge, W. D., and Moore, C. N.: Some Experiments with High Voltage Cathode Generating Tube. Jour. Franklin Inst., **202,** December, 1926.
7. Crane, H. R., Lauritsen, C. C., and Satan, A.: Production of High Speed Neutrons. Physical Review, **44,** October, 1933.
8. Desjardins, A. U.: Anatomical Cross-section Charts in Estimating X-ray Dosage. Am. Jour Roentgenol., **10,** 134–140, February, 1923.
9. Idem: The Principle of Absorption and the Method of Multiple Converging Beams. Am. Jour. Roentgenol. and Rad. Ther., **27,** 755–761, May, 1932.
10. Duane, W.: Roentgen Rays of Short Wave Lengths and Their Measurement. Am. Jour. Roentgenol., **9,** 167–171, March, 1922.
11. Duane, W., Hudson, J. C., and Sterling, H. N.: Measurement of Effective Wave Lengths. Am. Jour. Roentgenol. and Rad. Ther., **20,** 241–245, September, 1928.
12. Erskine, Arthur W.: Practical X-ray Treatment. Bruce Publishing Co., St. Paul, Minn.
13. Failla, G.: A New Instrument for Measuring X-radiation. Radiology, **15,** 437–448, October, 1930.
14. Idem: The Measurement of X-ray Dosage by Physical Means. Radiology, **13,** 293–305, October, 1929.
15. Idem: Relative Effects Produced by 200 kv. Roentgen Rays, 700 kv. Roentgen Rays, and Gamma Rays: Correlation of Experimental Results. Am. Jour. Roentgenol. and Rad. Ther., **29,** 352–362, March, 1933.
16. Idem: An Objective Method of the Administration of X-rays. Acta Radiol., **5,** 85, 1926.
17. Glasser, Otto, and Portmann, U. V.: The Physical and Clinical Foundations of Oversoft Roentgen-ray (Grenz Ray) Therapy. Am. Jour. Roentgenol. and Rad. Ther., **19,** 442–452, May, 1928.
18. Henshaw, P. S., and Francis, D. S.: Biological Measurement of Depth Dosage with 165 kv. and 650 kv. Roentgen Rays. Am. Jour. Roentgenol. and Rad. Ther., **34,** 789–797, December, 1935.
19. Jones, H. I.: Ionization Chambers for X-ray Dosage Measurement. British Jour. Radiol., **8,** 318, 1935.
20. Landauer, R. S.: Physical Aspects of Various Qualities of Radiation. Am. Jour. Roentgenol. and Rad. Ther., **32,** 235–238, August, 1934.
21. Idem: A Note on Zinc Filters. Radiology, **26,** 478, 479, April, 1936.
22. Lauritsen, Charles C.: On the Relation between the Roentgen and the Erythema Dose. Am. Jour. Roentgenol. and Rad. Ther., **33,** 235, February, 1935.
23. Idem: Energy Considerations in High Voltage Therapy. Am. Jour. Roentgenol. and Rad. Ther., **30,** 380–387, September, 1933.
24. Lawrence, E. O., and Livingston, M. S.: Production of High Speed Light Ions without the Use of High Voltages. Physical Review, **40,** April, 1932.
25. Leucutia, T., and Corrigan, K. E.: The Present Status of Roentgen Therapy with Voltages above 200 kv.: Technical Development and Medical Application. Am. Jour. Roentgenol. and Rad. Ther., **31,** 628–662, May, 1934.
26. Litwer, H.: On the Determination of the Filter-working of Filters for Scattered Rays, and the Elimination of Scattered Rays by Other Methods. Acta Radiol., **16,** 74–76, 1935.
27. Mayneord, W. V., and Roberts, J. E.: Ionization Produced in Air by X-rays and Gamma Rays. British Jour. Radiol., **7,** 158–175, March, 1934.
28. Idem: The Quality of High Voltage Radiations British Jour. Radiol., **8,** 341, 1935.

28a. MAYNEORD, W. V.: Physics of X-ray Therapy. J. and A. Churchill, 104 Gloucester Place, London, England.

29. MUTSCHELLER, A.: Thicknesses of Aluminum to be Used in Addition to Copper Filter. Am. Jour. Roentgenol. and Rad. Ther., **32,** 92, 93, July, 1934.

30. PARKER, H. M.: The Dependence of Back-scattering of Roentgen Rays in a Phantom on Focal Distance, Quality of Radiation, and Field Size. Acta Radiol., **16,** 705–715, 1935.

31. PARKER, H. M., and HONEYBURNE, J.: The Distribution of Radiation in Deep X-ray Therapy. British Jour. Radiol., **8,** 684–696, November, 1935.

32. POHLE, ERNST A.: Theoretical Principles of Roentgen Therapy. Lea & Febiger, Philadelphia.

33. QUIMBY, EDITH H.: The Skin Erythema Dose with a Combination of Two Types of Radiation. Am. Jour. Roentgenol. and Rad. Ther., **17,** 621, June, 1927.

34. Idem: Comparison of Different Metallic Filters Used in Radium Therapy. Am. Jour. Roentgenol. and Rad. Ther., **13,** 330, April, 1925.

35. Idem: A Method for the Study of Scattered and Secondary Radiation in X-ray and Radium Laboratories. RADIOLOGY, **7,** 211–217, September, 1926.

36. QUIMBY, EDITH H., LUCAS, C. DEF., ARNESON, A. N., and MACCOMB, W. S.: A Study of Back-scatter for Several Qualities of Roentgen Rays. RADIOLOGY, **23,** 743–750, December, 1934.

37. QUIMBY, EDITH H., and MARINELLI, L. D.: The Influence of Filtration on Surface and Depth Intensities of 200 kv. X-rays. RADIOLOGY, **21,** 21–29, July, 1933.

38. QUIMBY, EDITH H., and DOWNES, HELEN R.: A Chemical Method for the Measurement of Quantity of Radiation. RADIOLOGY, **14,** 468–481, May, 1930.

39. QUIMBY, EDITH H., and PACK, GEORGE T.: Further Studies on the Skin Erythema with Combinations of Two Types of Radiation. RADIOLOGY, **15,** 30–38, July, 1930.

40. QUIMBY, EDITH H., COPELAND, MURRAY M., and WOODS, ROBERT C.: The Distribution of Roentgen Rays within the Human Body. Am. Jour. Roentgenol. and Rad. Ther., **32,** 534–551, October, 1934.

41. QUIMBY, EDITH H., and MCNATTIN, ROBERT F.: The Change in Quality of Roentgen Rays on Passing through Tissue. Am. Jour. Roentgenol. and Rad. Ther., **28,** 236–244, August, 1932.

42. QUIMBY, EDITH H., and MARINELLI, L. D.: A Study of Cones or Other Collimating Devices Used in Roentgen Therapy. RADIOLOGY, **26,** 16–26, January, 1936.

43. QUIMBY, EDITH H., and SARGENT, WINFORD G.: The Influence of the Diaphragm on the Applicability of the Inverse Square Law to X-ray Dosage. RADIOLOGY, **10,** 1–9, January, 1928.

44. TAYLOR, L. S., SINGER, G., and STONEBURNER, C. F.: Comparison of High Voltage Roentgen-ray Tubes. Am. Jour. Roentgenol. and Rad. Ther., **31,** 378–385, March, 1934.

45. TAYLOR, L. S., and SINGER, G.: Note on the Guarded Field X-ray Ionization Chamber. RADIOLOGY, **26,** 322–325, March, 1936.

46. THORAEUS, R.: Wall Thickness of Tube and Filtration. Acta Radiol., **17,** 161, 1936.

47. Idem: Experimental Investigations of Some Dosage Conditions in the Technic of Roentgen Treatment Used in Sweden. Acta Radiol., **16,** 169–176, 1935.

48. Idem: The Wall Thickness of Roentgen Tubes and its Influence on the Filtration in General and on the Function of the Tin Filter in Special. Acta Radiol., **17,** 161–168, 1936.

49. Idem: A Portable Secondary Standard for Roentgen-ray Measurements. Acta Radiol., **16,** 735–743, 1935.

50. TUVE, M. A.: Depth Dose Calculations for Super-voltage X-rays. RADIOLOGY, **21,** 289–295, September, 1933.

51. WEATHERWAX, J. L.: Physics of Radiology. Paul B. Hoeber, Inc., New York, 1931.

52. Idem: Physical Measurements of Radiation and Their Application to Therapy. Am. Jour. Roentgenol. and Rad. Ther., **15,** June, 1926.

53. Idem: Range of Penetration of Different Ray Qualities in Radiation Therapy. Arch. Phys. Ther., X-ray, and Radium, **16,** 600–604, October, 1935.

54. Idem: Deep Therapy Radiation—The Cyclopedia of Medicine (Piersol). Vol. **10,** 740–770. Davis & Co., Philadelphia.

55. Idem: A Comparative Study of Dosage Technic in Radiation Therapy. Am. Jour. Roentgenol. and Rad. Ther., **18,** 346–355, October, 1927.

56. WEATHERWAX, J. L., and ROBB, CHARLES: Water Phantom Intensity Measurements of High Voltage Roentgen Rays (200 kv. Peak) at 70 and 80 cm. Skin-target Distance. RADIOLOGY, **22,** 426–431, April, 1934.

57. WEATHERWAX, J. L., and WIDMANN, B. P.: Physical Factors in Radiation Therapy and Their Clinical Application. RADIOLOGY, **12,** 297–308, April, 1929.

58. WEATHERWAX, J. L., BRADLEY, R. A., BOWEN, DAVID R., LEDDY, E. T.: A Convenient and Accurate Method of Measuring Roentgen-ray Depth Dosage. Am. Jour. Roentgenol. and Rad. Ther., **15,** 169, February, 1926.

59. WEATHERWAX, J. L., and ROBB, CHARLES: Determination of Radiation Values in Lung Tissue with Variable Qualities of Radiation. RADIOLOGY, **14,** 401–409, April, 1930.

60. Idem: Water Phantom Intensity Measurements of High Voltage Roentgen Rays Produced by 127,000 Volts. Am. Jour. Roentgenol. and Rad. Ther., **27,** 749–754, May, 1932.

61. WEATHERWAX, J. L., and LEDDY, E. T.: Standardization of Ionization Measurements of Intensity and Measurements of Scattered and Secondary X-rays Effective in Producing an Erythema. Am. Jour. Roentgenol. and Rad. Ther., **10,** 488–497, June, 1923.

62. Idem: Further Studies of Ionization Measurements of Roentgen-ray Intensity. Am. Jour. Roentgenol. and Rad. Ther., **12,** 110–116, August, 1924.

63. Idem: A Practical Method of Constantly Measuring the Radiation from a Roentgen Tube with a Check against the Omission of Filters. Am. Jour. Roentgenol. and Rad. Ther., **12,** 271–279, September, 1924.

64. WILLIAMS, M. M. D.: Radiation from an Oil-immersed Therapy Tube. RADIOLOGY, **26,** 749–755, June, 1936.

65. ZINTHEO, C. J.: Variations in the Intensity and Quality of Roentgen-ray Output as Affected by the Angle to the Central Ray, the Roentgen Tube, and the Roentgen Machine. Am. Jour. Roentgenol. and Rad. Ther., **37,** 98–104, January, 1937.

CONCERNING THE DIAGNOSIS OF LESIONS IN THE LOWER SPINAL CANAL

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PAIN in the lower back, radiating into one or both legs is a common ailment; one for which many remedies have been proposed and probably as many theories of its etiology offered. Until comparatively recent years, most investigators' attention has been focused upon extraspinal causes: the sacro-iliac joints, postural deformities, fascial bands, taut pyriformis muscles, the vertebral articular facets, and ill-defined toxic, allergic, or infectious involvements of peripheral nerves. Intraspinal lesions, if considered at all, were listed near the end of the differential diagnosis. The steadily increasing number of reported cases of low intraspinal lesions causing low back pain, particularly herniated nuclei pulposa (1, 2, 3, 4, 5, 6, and many others), and hypertrophied ligamenta flava (7, 8, 9, 10, 11), prompts the suggestion that these lesions are far more common than generally supposed.

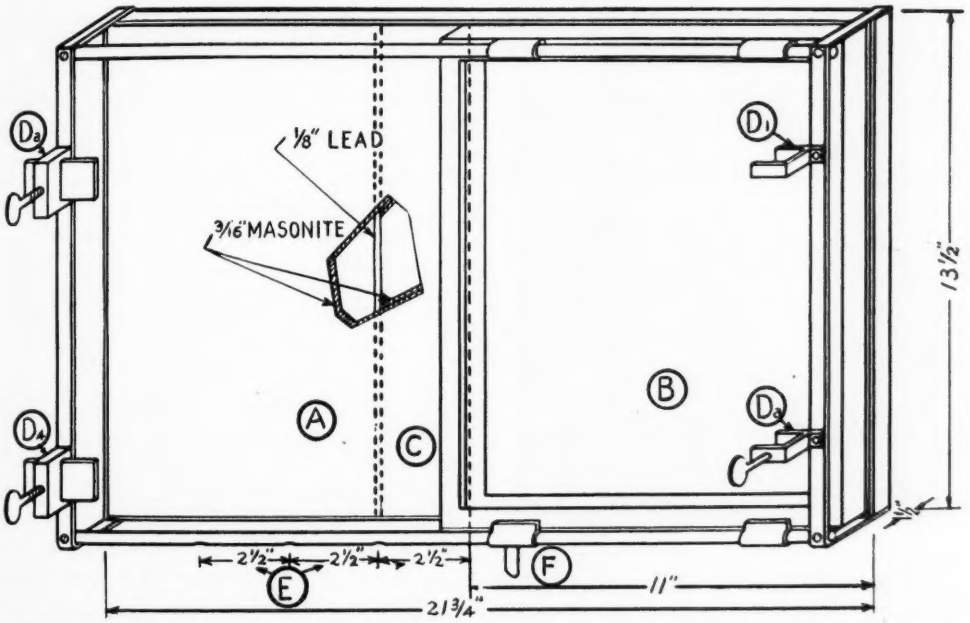

Fig. 1. Serial spinal tunnel showing construction, shifting mechanism, and provision for attachment to fluoroscopic screen. A—Lead-protected area for exposed portion of film; B—Lead-protected area for unexposed film; C—Unprotected area for fluoroscopic observation and serial film exposure; D—Apparatus for attaching tunnel to fluoroscopic screen; E—Stop-notches for control of shifting mechanism; F—Metal handle with spring plunger attached to movable cassette carrier.

Accurate localization of tumors in the lower lumbar neural canal from clinical findings alone has been and probably will continue to be, a difficult problem, due to anatomical peculiarities of the region. In the first place, lesions of the cauda equina may produce symptoms identical to lesions of the corresponding peripheral nerves. Unless

the lesion involves one nerve root alone and, therefore, gives pain, with or without sensory loss, corresponding to the segmental skin distribution of that root, it may be most difficult to localize its exact site. In the second place, many intraspinal lesions are sufficiently large to produce intractable pain, yet they yield negative findings on careful neurological examinations, such as normal sensory test, normal motor function, and normal reflex activity (see Fig. 5). This may be explained when one considers the large size of the neural canal in the lumbar region and the freely movable roots of the cauda equina. It is only as the roots leave the intervertebral foramina that they become relatively fixed. Therefore, a large lesion in this region may shift freely the caudal roots, except at their fixation points without producing destructive symptoms and signs.

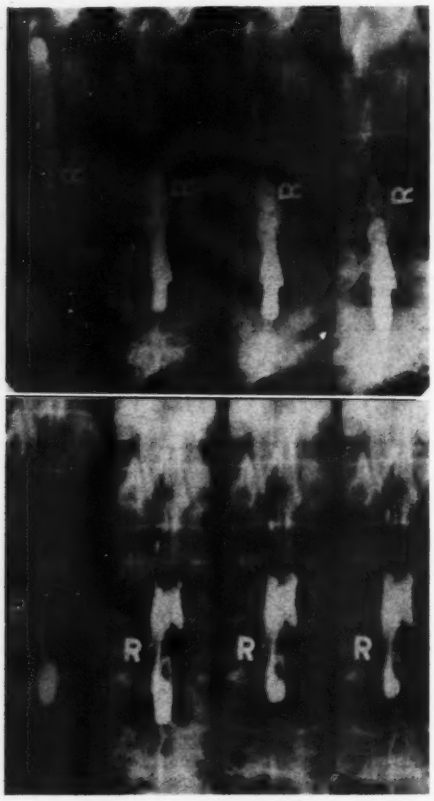

Fig. 2 (*above*). Normal lower spinal canal. Exposure on extreme right shows lipiodol column extending into sacral sac. Root sleeves well shown. The three exposures on left show column passing upward.

Fig. 3 (*below*). Large herniated nucleus pulposus at fourth lumbar interspace. Column shown passing progressively downward from exposure on right to the exposure on left. Large filling defect well shown.

Much of our progress to date in unraveling the mysteries of the lower spinal canal has been made possible by accurate roentgenological studies after injection into the subarachnoid space of some contrast medium for visualization. As our understanding increases, we may be able to relegate the laboratory tests to a place of secondary importance to the clinical study but that stage of development has not yet been reached.

Lipiodol and *air* have been used successfully for visualization of the neural canal. We freely admit that of the two, air is preferable insofar as local irritative effects are concerned, but when considered from the standpoint of accurate diagnosis of other than gross lesions, lipiodol is much superior. Lipiodol causes a local reaction in the meninges, the degree of which is largely dependent upon the presence of free iodine in the compound. Lipiodol when exposed to air liberates free iodine; therefore, the drug should not be used in the spinal canal unless preserved in glass ampules, the contents of which are injected with minimal contact with the air.

Most investigators to date have stated that lipiodol in quantities less than 5 c.c. gives incomplete information. We are in complete disagreement with this point of view. Two c.c. is considered to be the optimum amount, especially when used with the fluoroscopic and serial film technic which we are recording here. An amount in excess of 2 c.c. we consider to be a handicap for if the lesion is small it may be demonstrated only when a thin column of the opaque material is passing the point of involvement.

We shall not attempt a discussion of the virtues and dangers of lipiodol. Suffice it

to say, we have used lipiodol for localization of expanding lesions of the neural canal over a period of ten years and no permanent harmful effects have ever been observed when it was used in amounts not exceeding 2 cubic centimeters.

It must not be supposed that there can be any justification for lipiodol study of the subarachnoid space unless the patient has been subjected to a complete careful general examination and neurologic study. Such a study would naturally include plain roentgenograms of the spine and pelvis. If the neurologic study strongly indicates the presence of an intraspinal lesion, and if conservative methods have failed to bring relief of symptoms, then, and only then, should lipiodol injection be used. If this plan is followed very few negative examinations will be done.

The lipiodol is injected in the patient's room in the afternoon or evening before the examination. If the suspected lesion is low in the canal, the lumbar puncture is made at the second lumbar interspace. Injection made at the fourth or fifth lumbar interspace may be unsuccessful, for the needle may encounter the lesion, either a large nucleus or hypertrophied ligamentum flavum, and produce such severe pain that one may find it impossible to enter the subarachnoid space. A small sample of fluid for cell count and total protein determination is taken before lipiodol is injected. The patient's head is kept slightly elevated during the night to encourage the drug to gravitate to the lower spinal subarachnoid space. We have found the column to be smoother and to show less tendency to separate into droplets if the injection has been made several hours prior to the examination.

THE FLUOROSCOPIC EXAMINATION AND THE TECHNIC FOR MAKING FILMS

In our work we employ a serial film tunnel that has previously been described by one of us (12). The construction of the tunnel has recently been modified and the present model is illustrated in Figure 1. A tunnel of this type makes it possible to secure serial films in rapid succession while the column of lipiodol is in motion. It is attached to the fluoroscopic screen before

Fig. 4. Lateral view of same patient as shown in Figure 3. Ventral filling defect at fourth lumbar interspace.

the patient is placed on the table. A film is inserted into the cassette carrier and shifted so that it rests behind the lead-protected area. The fluoroscopic shutter is adjusted in such a manner that the opening is only sufficiently large to cover the area in the serial tunnel unprotected by lead. This opening is 2.5 × 10 inches and to expose this area a slit-like opening in the fluoroscopic shutter approximately 5 mm. wide is required. Because of the narrow opening in the shutter excellent detail is recorded on the film, the effect being almost the same as with a Bucky diaphragm. We employ a so-called quick change-over switch (13) which permits rapid shifting from fluoroscopic to radiographic setting and with which exposures can be made with minimal delay. We consider a switch of this type essential for a satisfactory lipiodol examination.

In the case of low spinal lesions it is our practice to place the patient prone on the fluoroscopic table with the feet resting against the support at the end of the table. A tilting table is used so that the position

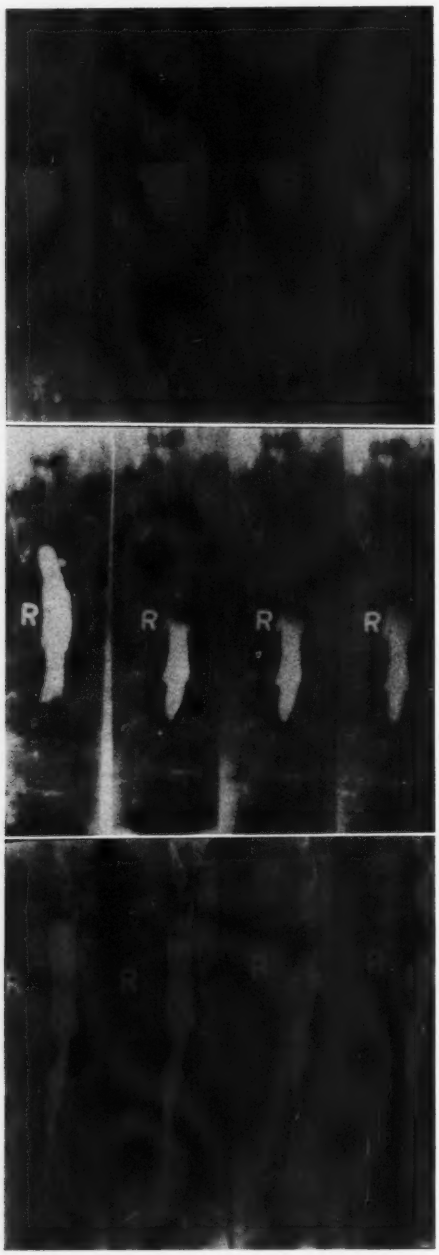

Fig. 5. Large herniated nucleus with complete subarachnoid block at level of fourth lumbar vertebra. Neurologic examination in this case completely negative. Only symptom, intractable pain over period of ten years.

Fig. 6. Small herniated nucleus pulposus at fifth lumbar interspace. Only defect noted was absent fifth lumbar root sleeve on left. Patient totally incapacitated by intractable pain in left leg for two years. Neurologic examination showed sensory loss in skin distribution of left fifth lumbar nerve.

Fig. 7. Small herniated nucleus pulposus at fifth lumbar interspace. Two exposures on right show an apparently normal column. The two exposures on left show column passing upward. As the column thins out the obvious defect on the right appears.

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may be changed from horizontal to upright at will. The patient's position is adjusted so that the portion of the spine being examined is directly beneath the unprotected area in the tunnel. Portions higher and lower may be examined by moving the screen with the attached tunnel upward or downward. The table is slowly tilted toward the upright and the progress of the lipiodol column is observed as it descends in the canal. If a filling defect is noted at any point serial films are made as the column passes this area.

The patient is raised until the column descends into the lowest limit of the sacral canal after which the head is gradually lowered and the progress of the material is observed as it passes upward in the canal. The progress of the column upward is observed to a point well above the level under suspicion as indicated by the neurologic study. No abnormality may be observed in the lipiodol column during the fluoroscopic examination in an area where the neurologic examination indicates that there is pathology. In this circumstance we make serial films of the suspected area while the column is passing it, for on more than one occasion a lesion has been shown in films that has not been detected with the fluoroscope. The value of the films made in the oblique positions has been discussed by previous writers (6). We have found such films to be most helpful in demonstrating small lesions and we now use them routinely.

Theoretically, one should be able to distinguish between a displaced nucleus and an hypertrophied ligament by lateral films. However, this is seldom the case, for nuclei usually herniate lateralward beneath the nerve root and the ligaments

frequently hypertrophy more on one side than the other. We have found it impossible in most cases to differentiate the two lesions by lateral films and, therefore, they are now used infrequently.

produce gross filling defects in the portion of the subarachnoid space where they are found. Such filling defects are readily demonstrated and at times produce a "complete block" below the level of which

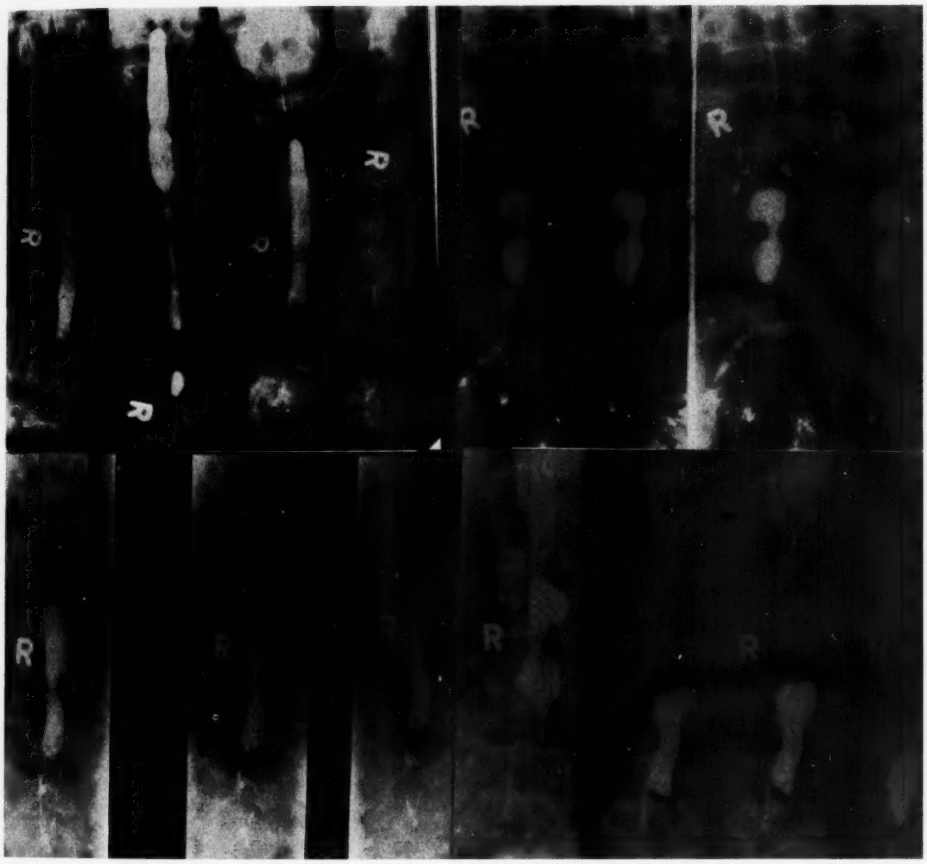


Fig. 8 (*above left*). Small herniated nucleus pulposus fourth lumbar interspace. Films made at different levels as column passes upward and downward in canal. Findings considered to be negative. Small partial filling defect at fourth lumbar interspace overlooked.

Fig. 9 (*below left*). Same case as Figure 8. Films made six months later without re-injection of lipiodol. Obvious filling defect at fourth lumbar interspace on left now present.

Fig. 10 (*above right*). Hypertrophied ligamentum flavum fifth lumbar interspace. Major defect on right side. Symptoms were low back pain radiating into right leg. Examination showed sensory loss in all sacral segments.

Fig. 11 (*below right*). Combined lesion: hypertrophied ligamentum flavum fourth lumbar interspace on left; herniated nucleus pulposus fifth lumbar interspace on right.

INTERPRETATION OF ROENTGEN-RAY FINDINGS

Large lesions, whether herniated nuclei pulposa, ligamenta flava, or neoplasms, it is impossible for lipiodol to descend by gravity (Figs. 5 and 12).

Small lesions may encroach upon the subarachnoid space slightly, if at all, yet

a lesion so small that demonstration by x-ray is difficult, may produce fulminating, disabling symptoms. Fortunately, in these cases the neurologic study usually indicates the probable location of the lesion

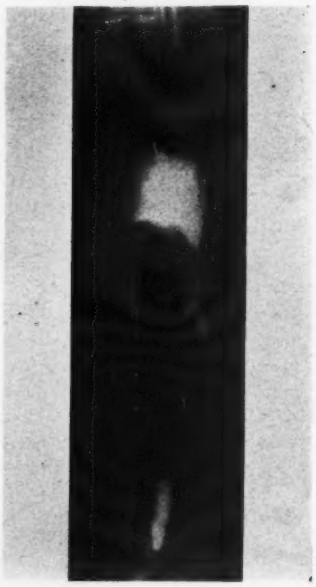


Fig. 12. Neurofibroma at level of fourth lumbar vertebra. Almost complete subarachnoid block. Only symptom, pain radiating into left leg. Neurologic examination negative.

and as a result the roentgenologist may use these findings as a guide for his study. Obviously, fluoroscopic examination alone in such a case may be of little help inasmuch as no gross defect in the lipiodol column is produced. It is only when viewed on the serial films that abnormalities about the root sleeves and small variations in the shape of the lipiodol column are observed. Furthermore, at times these small defects are not demonstrated during the downward passage of the lipiodol column. It may be only in the upward passage, when the column becomes relatively thin, that they become apparent (Figs. 6, 7, and 8).

The filling defects produced by herniated nuclei depend upon the size of the cartilaginous mass extruded into the canal and the place where it comes to rest. Most of our cases have shown unilateral filling defects (Figs. 7, 9, 10). Two have shown a complete block (Fig. 5). There was also a complete block of the canal with symptoms identical to those in the two just mentioned with herniated nuclei in the case illustrated in Figure 12; but in this instance the block was due to a neurofibroma.

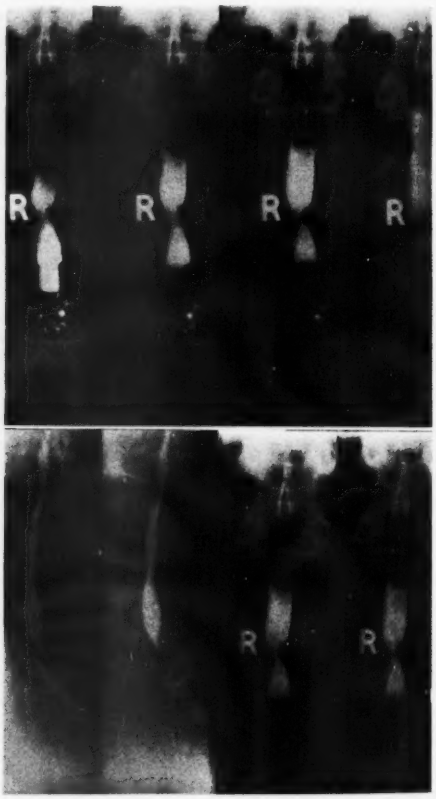


Fig. 13 (*above*). Constant filling defect fourth lumbar interspace. Films show column of lipiodol passing progressively downward through the area of narrowing in the canal. Large herniated nucleus pulposus removed at operation.

Fig. 14 (*below*). Anteroposterior and lateral films of same patient as Figure 13. These two illustrations show the kind of films that are secured with our present technic and equipment.

In some instances the extruded nucleus may come to rest in the intervertebral foramen and impinge upon the root of the corresponding nerve with consequent

irritation of the nerve due to pressure. This is followed by swelling of the affected nerve and may cause obliteration of the space about the root (choked root, Fig. 6).

There is great variability in the filling of the root sleeves. It is our impression that they are more readily demonstrated if the lipiodol injection is done some hours prior to the roentgenographic examination. It is certain that an absent root sleeve should not be considered abnormal unless the neurologic examination shows definite evidence of disease at this level. The position of the root sleeve is frequently abnormal in either of the lesions under consideration due to pressure upon the nerve by the lesion.

In hypertrophy of the ligamenta flava the enlargement is usually asymmetrical, and involves chiefly, one or the other of the lateral extremities of the ligaments and for this reason they usually produce unilateral defects (Fig. 10). However, we had one case in which there was a complete subarachnoid obstruction, and not infrequently an "hour-glass" defect is observed.

Combined lesions may be present and result in multiple filling defects at different levels. An illustrative case is shown (Fig. 11). The large filling defect on the left at the fourth lumbar interspace was noted at the first examination but the defect on the right at the fifth interspace was overlooked. At operation a markedly hypertrophied ligamentum flavum was found at the fourth lumbar interspace and removed. All of the patient's symptoms disappeared except localized pain in the skin distribution of the right fifth lumbar nerve. Our films were reviewed and the then obvious filling defect on the right corresponding to the area indicated by the neurologic signs was found. At the second operation a small herniated nucleus pulposus was removed. This operation was followed by complete relief of all symptoms.

A careful review of our cases has failed to reveal any one finding or group of findings which will permit one to differentiate between abnormalities of the nuclei pulposa and ligamenta flava with any degree of certainty. Since the treatment of the two lesions is the same this lack of differentiation is of little practical importance.

Narrowing of the intervertebral joint space has been present in some of our cases with herniated nuclei but this has been by no means a constant finding. On the other hand, grossly narrowed joint spaces have been found frequently with nothing either in the neurologic or roentgen-ray findings indicative of pathology within the canal at the level of the narrowed space.

SUMMARY

The neurologic and roentgen-ray findings in two of the lesions that may cause low back pain have been discussed.

Illustrations showing the roentgen-ray findings in ten cases operated upon are included.

The opinions expressed are based on the study of 40 cases operated upon in which an hypertrophied ligamentum flavum, a herniated nucleus pulposus, or both, were found in each, and removed.

BIBLIOGRAPHY

(1) DANDY, W. E.: Loose Cartilage from Interverbral Disc Simulating Tumor of the Spinal Cord. Arch. Surg., **19,** 660–672, October, 1929.

(2) MIXTER, W. J., and BARR, J. S.: Rupture of the Intervertebral Disc with Involvement of the Spinal Canal. New England Jour. Med., **211,** 210–215, Aug. 2, 1934.

(3) MIXTER, W. J., and AYER, J. B.: Herniation or Rupture of the Intervertebral Disc into the Spinal Canal: Report of 34 Cases. New England Jour. Med., **213,** 385–393, Aug. 29, 1935.

(4) HAMPTON, A. O., and ROBINSON, J. M.: The Roentgenographic Demonstration of Rupture of the Intervertebral Disc into the Spinal Canal after the Injection of Lipiodol, with Special Reference to Unilateral Lumbar Lesions Accompanied by Low Back Pain with "Sciatic" Radiation. Am. Jour Roentgenol. and Rad. Ther., **36,** 782–803, December, 1936.

(5) BARR, J. S.: "Sciatica" Caused by Intervertebral Disc Lesions: Report of 40 Cases of Rupture of Intervertebral Disc Occurring in Low Lumbar Spine and Causing Pressure on Cauda Equina. Jour. Bone and Joint Surg., **19,** 323–342, April, 1937.

(6) LOVE, J. G., and CAMP, J. D.: Root Pain Resulting from Intraspinal Protrusion of Intervertebral Discs: Diagnosis and Surgical Treatment. Jour. Bone and Joint Surg., **19,** 776–804, July, 1937.

(7) TOWNE, E. B., and REICHERT, F. L.: Compression of the Lumbosacral Roots of the Spinal Cord by Thickened Ligamenta Flava. Ann. Surg., **94,** 327–336, September, 1931.

(8) PUUSEPP, L.: Kompression der Cauda Equina durch das verdickte Ligamentum Flavum: Tumor-

symptome, Operation, Heilung. Folia neuropath. estoniana, **12,** 38–48, 1932.

(9) ABBOTT, W. D.: Compression of the Cauda Equina by the Ligamentum Flavum. Jour. Am. Med. Assn., **106,** 2129, 2130, June 20, 1936.

(10) NAFFZIGER, HOWARD C., INMAN, V., and SAUNDERS, JOHN B. de C. M.: Lesions of the Intervertebral Disc and Ligamenta Flava. Surg., Gynec. and Obst., **66,** 288–299, February, 1938.

(11) SPURLING, R. GLEN, MAYFIELD, FRANK H., and ROGERS, JAMES B.: Hypertrophy of the Ligamenta Flava as a Cause of Low Back Pain. Jour. Am. Med. Assn., **109,** 928–932, Sept. 18, 1937.

(12) BELL, J. C..: Apparatus for the Study of Opaque Media in the Spinal Canal. Am. Jour Roentgenol. and Rad. Ther., **37,** 416–419, March, 1937.

(13) Idem.: Apparatus for Serial Radiography and the Demonstration of the Mucosal Relief in Gastrointestinal Examinations. RADIOLOGY, **24,** 143–152, February, 1935.

RADIUM PROTECTION

PREFACE

THE rapid increase in the use of radium during the last few years, resulting in the acquirement of large amounts of radium by various institutions, has brought with it the need for better safeguards and rules to protect the users from the radiation. The dangers arising from exposure to the radiation from radium are in some cases now well known; in others, still obscure and uncertain. Sufficient experience and data are now available, however, to show with fair conclusiveness that with reasonable precautions radium can be handled over a considerable period of years with no apparent harm.

On the other hand, serious injury has resulted from relatively short periods of work with radium in cases in which certain precautions were overlooked. Even when proper working conditions and suitable regulations exist, there is still the potential danger of excessive exposure as a result of improper use of safety equipment and violation of good practice. Since the injury does not become apparent immediately, workers may frequently be tempted to neglect routine precautions.

The National Bureau of Standards has been engaged in the standardization of radium for medical purposes since 1913 and during this period has measured nearly all radium offered for sale in this country. The large amount of radium which has passed through our laboratory has made it necessary to give considerable attention to this problem of radium protection. But, the study of the biological effects of the radiation falls outside the field of our activities, and when the problem arose of revising Handbook No. 18, setting forth proper conditions for handling radium in the light of present-day knowledge, we turned again to the Advisory Committee on X-ray and Radium Protection. The following members compose this Committee:

Representing International Safety Committee and National Bureau of Standards for X-rays: LAURISTON S. TAYLOR, Physicist.

Representing American Roentgen Ray Society: E. R. PENDERGRASS, M.D., University of Pennsylvania Hospital, Philadelphia, Pa; J. L. WEATHERWAX, Physicist, Philadelphia General Hospital, Philadelphia, Pa.

Representing Radiological Society of North America: R. R. NEWELL, M.D., Stanford University Hospital, San Francisco, Calif.; G. FAILLA, Physicist, Memorial Hospital, New York City.

Representing the American Medical Association: FRANCIS CARTER WOOD, M.D., St. Luke's Hospital, New York City.

Representing X-ray equipment manufacturers: W. D. COOLIDGE, Director, Research Laboratory, General-Electric Company, Schenectady, N. Y.

Representing the American Radium Society: CURTIS F. BURNAM, M.D., Howard A. Kelly Hospital, Baltimore, M.D.

In response to the Bureau's request, Dr. Burnam, Dr. Failla, Dr. Newell, Dr. Weatherwax, and Dr. Wood kindly undertook the revision of the handbook. Dr. L. F. Curtiss, representing the National Bureau of Standards for Radium, acted as secretary to the Committee.

The regulations set forth in the following pages are the results of their joint recommendations regarding safe methods of handling preparations of radium used in radium therapy. I wish to express to the Committee my sincere thanks for their co-operation in the preparation of this handbook.

LYMAN J. BRIGGS, *Director.*

1. GENERAL CONSIDERATIONS

Protection Rules and Their Application.—It is well known that over-exposure to the radiations emitted by radium or other

radio-active substances may result in serious injuries. However, the experience of the last twenty-five years provides a satisfactory basis for the protection of those engaged in radium work.

The most important point is for the radium worker to have an ever-present realization of the danger and to carry out all manipulations in such a way as to reduce the exposure to a minimum. If this principle is strictly adhered to, there is no danger of irreparable damage being done *before* warning signs manifest themselves.

The recommendations given in the following paragraphs are intended to serve as a guide to radium workers and employers. Naturally, they must be followed judiciously to meet special problems which may arise in different laboratories. It should be borne in mind, however, that whatever means of protection are provided in any particular laboratory or clinic, they must be sufficient to prevent permanent injury, whether local or systemic, when instructions are properly followed by the worker.

Before an individual is employed to handle radium, he shall be informed of the dangers involved. He shall then be instructed to make proper use of the necessary safety measures provided in the laboratory or clinic. It is suggested that radium workers familiarize themselves with the recommendations contained in this Handbook.

1.01. Protection for radium workers is required from the effects of (1) local over-exposure to radiation, especially upon the hands, and (2) over-exposure of the entire body.

1.02. In either case, adequate protection may be secured most readily by distance and brevity of exposure.

1.03 All manipulations shall be carried out as rapidly as possible and with the hands and body as far from the radium as practicable. No radium preparation must be allowed to come in contact with any part of the technician's body (especially the hands) at any time.

1.04. Radium workers shall not remain in proximity to radium when not engaged in necessary manipulations.

1.05. The chart, Figure 1, gives the combinations of lead thickness and distance for different amounts of radium, which provide adequate protection for exposures not exceeding seven hours daily. (*Note:*—Continued exposure of technicians for a number of years, under the conditions stipulated in the chart, has been found to be safe at Memorial Hospital, New York. The tolerance gamma-ray intensity derived from the chart is approximately 0.1 r per day.) Table I gives typical values obtained from the chart to illustrate its use.

TABLE I

Milligrams of Radium	Thickness of Lead	Distance
10	0.5 cm.	70 cm.
	1 cm.	60 cm.
	2 cm.	45 cm.
100	1 cm.	185 cm.
	2 cm.	140 cm.
	3 cm.	105 cm.
1,000	1 cm.	570 cm.
	3 cm.	340 cm.
	6 cm.	160 cm.
5,000	4 cm.	550 cm.
	6 cm.	350 cm.
	10 cm.	220 cm.

1.06. All storage containers shall be at as great a distance as convenient from any place habitually occupied by any person, but in no case shall the combination of distance and screening (whether by lead or equivalent thicknesses of other materials) be less than indicated in the above-mentioned chart.

1.07 It is recommended that whenever possible the amount of radiation to which a person is subjected during the entire working day be measured by a suitable integrating device over a long enough period to be representative of average working conditions.

1.08 Photographic films carried in a pocket during working hours may be used as a rough test of protection. Ordinary "dental film" with a paper clip is convenient for this purpose. The paper clip helps to distinguish between exposure to hard gamma rays and exposure to soft radiation—largely beta rays. If the film

shows decided blackening after being carried two weeks, conditions should be investigated to determine whether this is due to local exposure or is indicative of the exposure which the entire body receives. In the latter case, steps should be taken to reduce the general exposure of the body to a safe limit. Moderate darkening of ordinary dental films in two weeks' exposure may be taken as a rough indication that the general radiation is within the tolerance limit. It should be borne in mind that film tests of this sort are not very satisfactory. X-ray films are so sensitive that a certain degree of darkening is always found in dental films carried by radium workers for two weeks. It is impossible to make a close estimate of the radiation received by the film without elaborate experiments and careful measurements of the photographic density. A film showing marked blackening from *local exposure* does not necessarily indicate dangerous working conditions.

II. PERSONNEL

2.01. The effects on the human body of continued exposure to low radiation intensities are not well known.

(*a*) Over-exposure of the entire body or a large part thereof may cause eventually a lowering vitality, with a general feeling of lassitude and frequent headaches.

(*b*) Extreme over-exposure of the entire body may result in the development of anemia or, possibly, leukemia.

(*c*) Over-exposure of some part of the body (*e.g.*, the hand) may result in local "radium burns" which are very refractory to treatment and may eventually become malignant.

2.02. Complete blood counts shall be taken every month for persons regularly working with radium.

(*a*) A complete blood count consists of the following determinations: Hemoglobin test, red, white, and differential counts, the latter including percentages of polymorphonuclear cells, small and large lymphocytes (separately), eosinophiles, and basophiles. In addition, a blood-platelet, sedimentation, and coagulation tests are of value.

(*b*) Blood counts of one individual taken at different times of the day may vary considerably. Accordingly they should always be taken at the same hour, particularly, with respect to meals. If possible, the same technician employing the same method and technic should take all counts for one individual.

(*c*) Blood counts of different individuals may vary considerably within normal limits. Therefore, the absolute values of the different counts are not so important as the relative values of corresponding counts from month to month. A downward trend of the white count and of the percentage of polymorphonuclear lymphocytes, over a period of a few months, may be taken to indicate the possibility of over-exposure. The matter should be investigated immediately.

(*d*) Before employing a technician for radium work, a complete blood count should be taken. This, together with the first few monthly counts (before appreciable change from radiation may occur), may be taken as the normal count for the individual. No one should be employed as a radium technician if there are unaccountable abnormalities in his blood count.

(*e*) In appraising the significance of changes in blood counts within the first few months, all factors should be considered, including particularly the previous occupation of the individual (*e.g.*, whether outdoors or indoors).

(*f*) Since blood counts of normal individuals ordinarily vary within wide limits among themselves and from time to time for the same person, one must beware lest a blood count which is within these limits, lull one into a false sense of security. As already pointed out, more attention must be paid to the trend of successive counts than to absolute values. It is suggested that all counts

be made under the direction of a skilled hematologist to detect the earliest deviation from normal.

2.03. A thorough physical examination of a radium worker should be made before he is employed and at any time that the blood count shows suspicious changes or the individual complains of some obscure ailment. In the physical examination, particular attention should be given to teeth, tonsils, and focal infections, also to the condition of the skin on the hands.

(*a*) Individuals with dry skin having a tendency to crack, a skin with warts, or a skin showing signs of abuse (cuts, cracks, etc.), should not be employed for radium work. (Dirty nails indicate that an individual is apt to abuse his hands in manual work and he should not handle radium.)

2.04. The hands of a radium technician shall be examined at regular intervals.

(*a*) The first effect of local exposure manifests itself as a reddening and shiny appearance of the skin of the fingers next to the nails.

(*b*) Later, nails may assume an abnormal curvature, either up or down, and with continued exposure become brittle.

(*c*) The skin at the end of the index finger and the thumb may become somewhat leathery and may lose its characteristic ridges. This may be taken as a definite indication that the individual is careless and, on occasion, handles radium with his fingers.

(*d*) At what stage the individual should stop working with radium depends on circumstances. However, a radium technician should be informed of the occupational hazards at the outset and should be reminded of them from time to time. He should not be promised permanent employment.

2.05. Individuals with faulty vision, which cannot be corrected properly by glasses, shall not be employed for radium work.

2.06. Radium technicians who have been employed more than a year should have four—and preferably six—weeks' vacation a year. This should be arranged to permit four weeks during the summer and two in winter. Technicians should be urged to spend as much time as possible outdoors, both during vacation and after working hours. If other methods of reducing exposures, such as intermittent employment in radium work, are used, the vacation period can be reduced.

2.07. Precautions shall be taken to protect nurses in charge of patients receiving radium treatments, and other persons who, in the performance of their duties, are subjected to radiation from patients under treatment.

(*a*) Distance and length of exposure are the two factors which can be controlled most readily for the protection of such personnel.

(*b*) Table II gives the distances at which it is safe for a person to be, for a period of years, from patients receiving different milligram-hour doses daily. (The influence of walls and objects in the path of the rays has not been taken into account in Table II).

TABLE II

Daily Exposure (mg.-hr.)	Safe Distance (meters)
100	0.9
200	1.3
400	1.8
800	2.5
1,600	3.6
3,200	5.0

(*c*) Nurses who regularly attend to patients being treated with radium should perform their duties which bring them close to the radium as rapidly as possible and should then remain as far as practicable from the patient or patients.

2.08. In institutions where large quantities of radium are used for the treatment of patients special precautions shall be taken to prevent over-exposure of nurses and secretaries as well as radium technicians.

(*a*) The nature of these precautions depends largely on local factors and

conditions. It is suggested that, whenever possible, nurses assigned to radium cases be rotated and that patients receiving radium treatments be widely separated.

(*b*) Monthly blood counts should be taken if a preliminary survey based on the figures of Table II suggests the possibility of over-exposure.

III. STORAGE

3.01. When not in use or transit, all radium shall be stored in a protective inclosure.

3.02. This inclosure shall provide sufficient protection to all persons, whether employees or not, who may periodically come within the "danger range" of radium. The "danger ranges" of different quantities of radium filtered by no less than 1 mm. of lead or its equivalent, for different daily exposures, are given in Table III.

TABLE III[1]

Amount of Ra. El. (mg.)	Daily Exposure in Hours: 1	2	4	8	16
	Danger Range in Meters				
100	0.9	1.3	1.8	2.5	3.6
200	1.3	1.8	2.6	3.6	5.1
400	1.8	2.5	3.5	5.0	7.1
1,000	2.9	4.0	5.7	8.0	11.3

[1] Values based on Protection Chart, Figure 1.

3.03. The amount of absorbing material to be provided in any one direction depends on:

(*a*) The distance at which the person to be protected may be.

(*b*) The period of time during which the person may remain at this distance.

(*c*) The influence which the amount of absorbing material affording sufficient protection in any given direction may have on the intensity of radiation at other points to be protected. (*Note:*—It is not sufficient to place a large quantity of radium near an outside corner of a room behind a lead plate, no matter how thick. The protection for people outside will be more than sufficient, but inside the room there may be too much scattered radiation.)

3.04. In any event, sufficient protection shall be provided to reduce the general body radiation to which a person may be exposed to 0.1 r per day for the person in question.

3.05. In the case of individuals who are apt to handle radium for a number of years, account must be taken of the exposures and correspondingly greater protection from stored radium must be provided.

3.06 The protective inclosure may be constructed of any suitable material. If any material other than lead is used, it is important that the equivalence to the necessary lead thickness, derived from the protection chart for any given case, be determined under proper conditions. Absorption measurements made with narrow beams of gamma rays are not satisfactory for this purpose.

3.07. The protective material should surround the radium and should be as close thereto as practicable. This is not only more economical but makes the source of scattered radiation (the inclosure itself) smaller. (*Note:*—A large concrete wall of insufficient thickness to absorb *all* the radiation provides more scattered radiation into an adjacent room than the same thickness of concrete placed immediately around the radium.)

3.08. The protective inclosure shall be constructed in such a way as to minimize as much as possible the exposure of technicians in the handling of the radium. The most important factors to consider are:

(*a*) Distribution of the radium.

(*b*) Protection of subdivided amounts.

(*c*) Time required by technician to remove or return a particular applicator to the inclosure.

3.09. The radium supply should be subdivided in small lots in the protective inclosure, each lot being placed in a suitable, protected compartment. The number of tubes or needles which may be placed in each compartment, depends on the radium content of the preparations and the number of units which are generally grouped

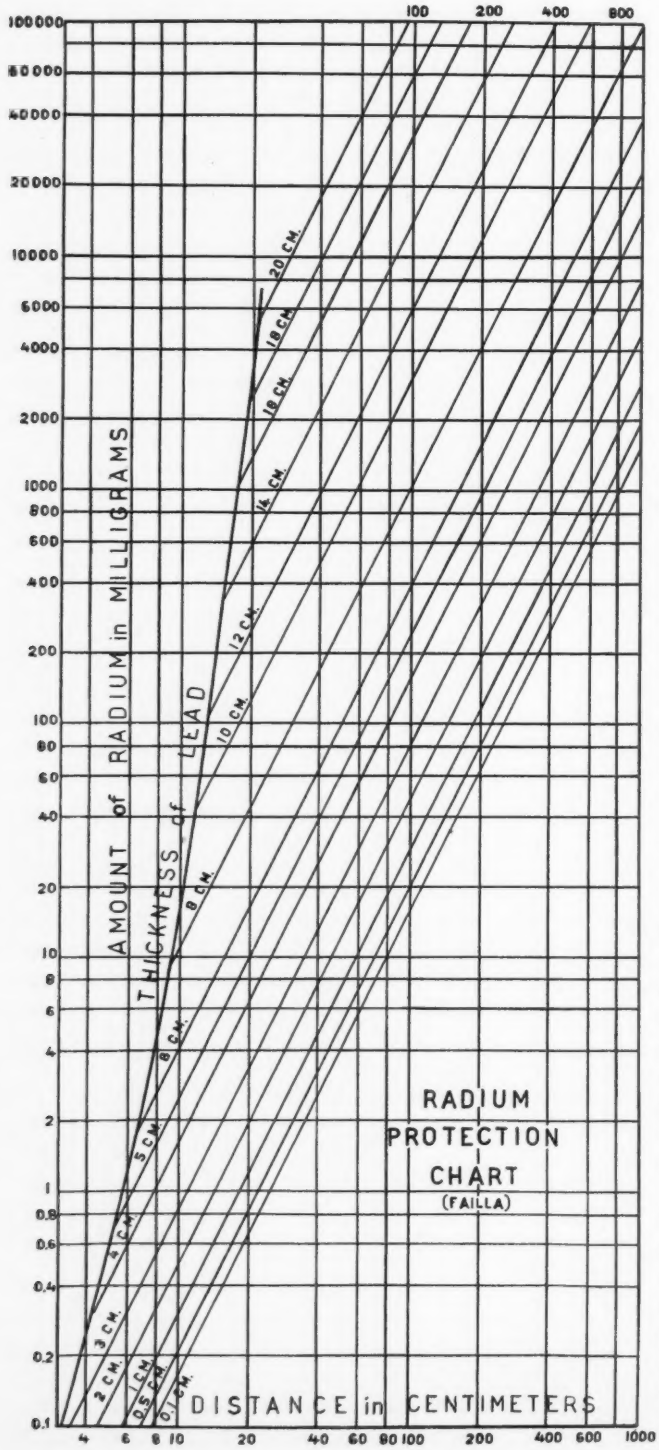


Fig. 1. Radium protection chart showing distances at which it is considered safe for an individual to be for a number of years during working hours (not exceeding eight hours daily) for various amounts of radium and lead screening. The chart is based on actual experience with radium technicians. It is interesting to note that under the conditions stipulated in the chart, the individual is exposed to approximately 0.1 r per day, which is within the range of tolerance intensity generally accepted for x-ray workers.

together in the treatment of average cases.

3.10. Separate compartments should be provided for different types of applicators and for those of distinctly different radium content.

3.11. Each compartment should be labelled or otherwise marked so as to permit immediate and certain identification of its contents from the outside.

3.12. It is highly desirable that tubes, cells, needles, etc., be readily identifiable from a considerable distance as to their radium content. When sizes and shapes are not adequate other means should be employed, such as plating or enamelling with different colors.

3.13. The protection of the individual compartments and the inclosure as a whole should be such that a technician standing in front of the inclosure in performance of his duties receives in that time only a fraction of the allowable daily body dose.

IV. MANIPULATION AND PREPARATION

4.01. The exposure to radium radiations of technicians, nurses, and all individuals who handle radium, shall be reduced as much as practicable by providing suitable equipment and accessories.

4.02. Such equipment shall be designed to permit the necessary operations to be carried out expeditiously at a considerable distance, and behind protective screens—the three factors being properly adjusted with respect to the influence of one upon the others.

4.03. The preparation of radium applicators or similar operations shall be carried out behind a lead L-block of a minimum thickness of 5 cm. in the direction of the technician, and of such size as will shield the entire body.

(*a*) The block should be of such height that when placed on a table, the technician can look over the edge comfortably when standing.

(*b*) The top of the L-block should be provided with an inclined lead glass "visor" equivalent to at least 1 mm. of metallic lead, if unfiltered radium or radon is to be handled.

(*c*) The side of the block next to the technician should have a protective pad to keep his body at least 20 cm. from the point where the radium is handled.

(*d*) The inside corner of the L should be curved so as to increase the lead thickness at the level where the radium is closest to the body and to insure that the manipulations are carried out at a considerable distance from the corner.

(*e*) The lead block should be covered with wood, "linoleum," or other material of low atomic weight.

4.04. Vises or clamping devices should be provided at the lead block to facilitate preparation of applicators. Preferably these devices should be operated by foot pedals.

4.05. Forceps for handling radium should be designed specially for this use. In general:

(*a*) They should be as long as the operation to be carried out permits, taking into account speed and preciseness of manipulation.

(*b*) They should grip the radium containers firmly with a minimum of force exerted by the fingers. Spring operated self-clamping forceps are desirable where practicable. The jaws should be notched, grooved, or otherwise formed to fit the applicators to be handled.

(*c*) Forceps 25 to 30 cm. long are recommended for general purposes. They should be light in weight to permit rapid and accurate manipulation. If unfiltered specimens are to be handled, forceps should be provided with metal gauntlets of sufficient thickness to absorb all primary beta rays.

(*d*) Forceps used to lift easily damaged preparations should have a "spring tip" adjusted to prevent excessive pressure on the specimen.

(*e*) Cross-action forceps are desirable for some delicate manipulations.

4.06. A suitable device should be provided for threading needles or tubes expeditiously with the fingers protected as much as possible by distance and lead barriers.

4.07. Rooms in which radium is handled must be properly lighted and ventilated. Special operations may require individual lighting.

4.08. A lead-lined "well" should be provided near the lead L-block, to hold radium preparations required for an applicator while it is being made up. The "well" should be covered by a heavy lead top on suitable rollers so that it can be moved to the open position by a foot lever and returned to the closed position by gravity.

4.09. Radium technicians should be supervised to make sure that they take advantage of the protective devices provided. Injuries from over-exposure to radium rays do not manifest themselves for days, weeks, or months. This is apt to lead to carelessness. New technicians must be instructed properly at the start, and the dangers of over-exposure impressed

on them. All operations should be planned outside the preparation room and then carried out rapidly, so that the time spent in handling the radium is only that absolutely necessary to carry out the required manipulations.

4.10. In spite of all precautions, radium technicians who work with large quantities of radium are subjected to higher radiation intensities than those to which it is definitely safe to be exposed for several years. When this is the case, blood counts and fingers should be watched carefully, and appropriate steps taken as soon as indications of slight over-exposure appear.

V. RADON PLANTS

5.01. To avoid danger of inhalation of radon by the operator, thorough ventilation (at least eight complete changes per hour) of the room in which radon pumping equipment is located is essential. Exhaust fans should draw air from near the floor and discharge it into the open air through as short ducts as practicable. Ventilation fans should be turned on at least a half-hour before the room is to be occupied, unless means are provided to detect possible leakage of radon.

5.02. Lead screening shall be provided for all parts of the radon apparatus in which radon accumulates, including the connecting glass tubing where the most radon will collect.

5.03. Manipulations of radon bulbs and seeds shall be carried out as far as possible immediately after they have been sealed from the pumping apparatus, while the active deposit is at a minimum.

5.04. Automatic pumping equipment or apparatus equipped with remote controls is recommended for radon pumping.

5.05. Exposures are of the same character as for radium of the equivalent amount of filtration. Therefore, all recommendations contained in this handbook for screening, storage, and manipulation of radium preparations apply equally to preparations of radon.

VI. TRANSPORTATION WITHIN AN INSTITUTION

6.01. Containers for carrying radium shall provide adequate protection from local injury (*e.g.*, burns) and general systemic disturbances in individuals handling the container, based on the longest possible time that the individual may carry the package or packages at any one time or repeatedly in the performance of his duties.

6.02. The required protection may be obtained by a suitable combination of lead screen completely surrounding the radium.

(*a*) Radium carriers should be designed to conform with the specifications given in Table IV as to lead thickness and distance of the radium from the handle.

(*b*) The handle of the carrier should be so arranged that it is easier to carry it by the handle than in any other way.

(*c*) Hand carriers should not weigh more than 10 kg. and should be provided with long handles which bring the radium close to the floor in the normal carrying position. The lead lining at the bottom may be half as thick as that of the sides and top.

TABLE IV

Amount of Radium (mg.)	Lead Thickness (or Equivalent) (cm.)	Minimum Distance from Radium to Handle (cm.)
10	0.1	25
	1.0	18
20	0.1	35
	1.0	26
40	0.1	50
	1.0	37
100	1.0	60
	2.0	45
200	2	64
	3	50
400	2	90
	3	70
1,000	2	140
	3	110
	4	80

(*d*) Radium carriers which weigh much more than 10 kg. should be mounted on wheels.

(*e*) All radium carriers should be constructed so as to reduce to a minimum the time required to place applicators therein and remove them and at the same time permit all operations to be carried out with the technician's hands at a considerable distance from the radium.

6.03. In the case of an individual who may transport radium for many years, the average total dose must not exceed 0.1 r per day. In estimating the body dose, one may take the distance of the radium from the umbilicus as a rough approximation to the average effective distance.

6.04. It is suggested that, especially in institutions or laboratories where large quantities of radium are handled, radium technicians be relieved as far as practicable from the task of transporting radium preparations from one room to another. This may well be done by employees who are not continually exposed to radiation. It should be noted in this connection that the specifications of Table IV are not so stringent as those for the storage of radium. The body dose resulting from carrying radium seven hours a day under the conditions set forth in the table is approximately 1 r per day.

6.05. When radium is transported from a hospital or laboratory to a doctor's office or patient's home, precautions should be taken to prevent injury to the person carrying it.

(*a*) The radium carriers for this purpose may be those used for transporting radium within the hospital proper, or they may be specially designed, depending on conditions.

(*b*) Insofar as practicable, technicians regularly engaged in radium work should not be required to transport radium in this way. At any rate, the exposure to which a technician is subjected in the course of transporting radium must be taken into account.

(*c*) Individuals who transport radium regularly in public conveyances shall be instructed to place the container on the floor and to stand, rather than sit, near it. In automobiles, radium should be placed as far as possible from persons who work with it regularly.

6.06. When radium is sent out of the hospital or laboratory by a messenger who is not familiar with the dangers of overexposure, the container or package shall be such as to preclude the possibility of local injury.

(*a*) The combination of lead thickness and minimum distance of the radium from the surface of the container given in Table V provides sufficient protection from *local injury* with a large factor of safety:

TABLE V

Amount of Radium (mg.)	Lead Thickness (or Equivalent) (cm.)	Minimum Distance from Surface (cm.)
10	0.1	3.5
20	0.1	5.0
	0.5	4.4
	1.0	3.75
50	0.1	7.9
	0.5	6.9
	1.0	5.9
100	0.1	11.1
	0.5	9.8
	1.0	8.3
200	0.1	15.7
	0.5	13.7
	1.0	11.7

(*b*) It is desirable to add a handle to the box or container to bring the radium close to the floor in the normal carrying position.

(*c*) Special carrying cases may be provided for such transportation of radium. If they are constructed in such a way that in the obviously most comfortable carrying position the radium is close to the floor, they may be of smaller dimensions than indicated in Table V.

VII. TRANSPORTATION BY COMMON CARRIERS

7.01. Shipment of radium, radon, or similar radio-active substances through the mails is prohibited by postal regulations

in the United States. This regulation is intended to prevent fogging of photographic films.

7.02. Shipment of radium up to 100 mg. in a single shipment may be made by railway express when the package is plainly marked as containing radium and is provided with lead screening sufficient to protect super-speed X-ray films. Details may be obtained from local express agents.

VIII. UNUSUAL CONDITIONS

8.01. It is impossible to deal with unusual conditions within the scope of this handbook. Among such are refineries of considerable amounts of radium, unusually large amounts of radium in a single institution. It is the opinion of the Committee that in such situations a special survey should be made, with competent expert advice to determine necessary safeguards.

WHAT IS THE ISSUE?

For a number of years there has existed a controversy, which occasionally and in certain communities has flared into warlike proportions, between organized hospitals and the organized medical profession concerning the practice of medicine in hospitals. Particular interest has centered around the specialties of radiology, pathology, anesthesiology, physical therapy, and others which are closely identified with the treatment of patients during hospitalized illness.

During recent years the question has been brought to a head by the advent of hospital insurance and by the determination on the part of some hospital administrators, met by decreasing endowment income, to augment hospital income from fees paid for medical services performed in the hospital. To make hospital insurance more salable they have demanded that certain medical services be included in the benefits offered by the hospital. To secure needed revenue they have employed specialists on a salary or commission basis, sufficiently low to permit, in some cases, a net income to the hospital after all expenses are paid.

Organized medicine has steadfastly insisted that the quality of medical care and the future progress of medicine will suffer if private practice be supplanted by institutionalized practice, delivered, sold, and controlled by a third party corporation, hospital or otherwise. Medical practice, says the profession, is the function of doctors and the physician's relation to his patients must not be complicated by a corporate distributing agency. Hospitals, they say, are institutions where doctors may treat the sick, retaining the same professional relationship with the patient that they have in the home or private office.

The American Hospital Association, representing the organized hospital world, has, with a good deal of emphasis, expressed an opposite view. The hospital, they say, is more than a place where doctors treat their patients. It is an institution which provides not only facilities but medical service. In this day of corporate structure and mass production, the hospitals say their function includes the provision of certain medical services through the medium of employed physicians under salary or commission contracts.

With diametrically opposed "principles" promulgated by first one side and then the other, and with prejudiced opinion presented as fact, it seems desirable that an attempt be made to clearly define the issues.

The medical profession recognizes that improvements in hospital facilities and administration have been partly responsible for the tremendous strides of medical science and the high quality of medical care enjoyed by the American people to-day. Hospital administrators are no less generous in their praise of the physician for his humanitarian contributions to the public welfare.

The differences arise in the field of economics. The medical profession demands that the hospital meet its financial obligations with revenues from its endowments, its income from charities, its profits on the rental of its rooms and facilities and the sale of its *hospital* services. It denies the hospital's right to earn a profit from the sale of physicians' services.

The American Hospital Association insists that the hospital has a right to provide certain medical services, along with its hospital facilities. Says the Board of Trustees of the A.H.A., "Provision of medical services in hospitals is part of the responsibility of the hospital." W. P. Slover, a hospital superintendent, writing in the Journal of the A.H.A., advises hospitals to increase their revenue by educating the public to "more regular use of the laboratory, the x-ray and diagnostic services for systematic check-ups on their health."[1] It seems apparent that this may place the hospital corporation in competition with private physicians. Editorially, the same Journal declares that, "Diagnosis, treatment, and care of the ambulatory sick become increasingly the function of the hospital, as the hospital develops into the center of community health activities."[2]

It is generally recognized that corporations, being artificial legal entities, cannot be licensed

[1] Hospitals, June, 1938, p. 50.
[2] Hospitals, May, 1937, p. 73.

and are, therefore, not permitted to practise medicine. Among hospitals there is a widespread belief that incorporated hospitals do not fall under this category. Says their official Journal, "The laws regulating the practice of medicine by corporations do not apply and were never intended to apply to hospitals."[3] No authority for the statement is cited. The Board of Trustees of the A.H.A.[4] is slightly contradictory when it attempts to justify corporate practice by declaring that it is not corporate practice. "The performance of diagnostic and therapeutic procedures by staff members constitutes the practice of medicine *in* hospitals. It is not the practice of medicine *by* hospitals," they say. Presumably this would be true even if such practice *in* the hospital resulted in an appreciable profit to the hospital corporation. The Board further states that, "The financial arrangement between a hospital and a physician is not a determining factor in the ethics or legality of medical practice."

The hospitals further contend that even if laws prohibiting corporate practice of medicine should apply to hospitals and if it be admitted that hospitals are actually practising medicine when they hire physicians, it is still correct to define radiology, pathology, and certain other specialties as hospital services instead of medical services. Apparently the hospitals are not too sure of their ground, else they would not find it necessary to provide three premises for the same syllogism. Hospitals which practise medicine for a profit do not practise medicine; anyway, laws prohibiting corporate practice do not apply to hospitals; and if these both be untrue, the services under question are not medical services but are hospital services.

"At what point can a line be drawn, if anywhere, between 'hospital' service and 'medical' service?" asks Michael Davis, a member of the Council of the A.H.A.,[5] implying that the one is the other. As a matter of fact, the question is not so difficult as it might appear. The terms are properly used—one is "hospital" and one is "medical." Numerous court decisions have defined the terms and according to Bouvier's Law Dictionary, "The primary meaning of the terms 'medical attendance' or 'medical services' is the rendering of professional medical services."[6] The Supreme Judicial Court of Massachusetts has held that, ". . .While the term 'medical services,' if used without limitation, may be susceptible of a broad construction, the statutes cited clearly indicate that those words, as therein used, are restricted to medical assistance rendered by the physician or under his direction and control."[7]

Physicians have delegated certain medical functions to be performed by nurses, interns, and other employees of the hospital under their direction, but these functions are performed by the hospital corporation through the sufferance and under the authority of physicians. It does not confer upon hospitals the right to indulge in the practice of medicine by themselves in disregard of the preference of physicians.

It is likewise true that the courts are well agreed that corporations cannot practise medicine and that this applies to hospital corporations. In Granger *v.* Adson[8] the Minnesota Supreme Court reasoned that inasmuch as a corporation or a layman could not practise law by employing a licensed attorney, for the profit of the corporation or layman employing him, to act as attorney or counsel for others, it was improper and contrary to statute and public policy for a corporation or layman to practise medicine in a similar way. Similar decisions have been rendered by courts in many other States.

When the editors of the Journal of the A.H.A. make the statement that, "The laws regulating the practice of medicine by corporations do not apply and were never intended to apply to hospitals,"[9] they are on unsound ground. This and a number of other statements emanating from hospital headquarters are rather convincingly refuted in a recent opinion by Judge J. F. Bouchelle, of West Virginia.[10] After citing considerable authority to support his opinion that a hospital corporation could not practise medicine, the Court concluded by saying, "In order that there be no misunderstanding as to the scope of this opinion, attention is directed to the fact that it is not intended to preclude contracts by individuals or corporations to furnish *hospital facilities* only. . . . Neither is it intended to prevent medical attention gratuitously contrib-

[3] Hospitals, June, 1938, p. 65.
[4] In a statement adopted June 18, 1938.
[5] The Modern Hospital, July, 1938, p. 57.
[6] Baldwin's Century Edition, p. 795.
[7] People *v.* Pierson, 176 N. Y., 201.
[8] Granger *v.* Adson, *et al.*, Minn. 250 N. W., 722.
[9] *Op. cit.*
[10] Amick *v.* Staats Hospital, in the Circuit Court of Kanawhat County, W. Va.

uted by doctors and surgeons to patients of incorporated charitable organizations."

For reasons of brevity it is impossible to quote the many court decisions or the statutory law bearing upon all the points raised in recent official statements by organized hospitals. It is sufficient to say that there is ample authority to disprove many of their contentions, granting at the same time that the courts are by no means completely agreed on some points.

By a rather vitriolic exception to certain principles adopted at the San Francisco session of the American Medical Association, organized hospitals have clearly defined the issue. Organized medicine wants the practice of medicine to be left to private physicians—organized hospitals demand that hospitals be privileged to take over certain specialties to be sold at a profit by the corporation. Especially are they insistent that in hospital insurance plans they be allowed to include certain medical services as benefits along with their hospital services. Medicine denies them this right, on the grounds that it alters the professional status of the physician and is contrary to public policy.

The Philadelphia County Medical Society went to court to enjoin local hospitals from proceeding with such a plan against the expressed desires of the profession. After several days of testimony before the Master, the attorneys for the hospitals agreed to accede to the demands of the county society and the plan was changed to separate hospital and medical services. Doctors who testified made it clear that they objected, not to insurance which paid cash benefits for medical services, but to the inclusion of these services as benefits *in kind* to be offered as a part of hospitalization.

Radiologists, pathologists, anesthetists, and others whose specialties are most coveted by the hospitals, hold to the same philosophy and ethical principles as does all organized medicine. While it is undeniably true that contractual relations between practitioners of these specialties and their hospitals have placed many of these physicians in the position of employees of the hospital corporation, the fact remains that theirs is a medical service and not a hospital service. Radiologists, for instance, have permitted hospitals to collect their fees, receiving in reimbursement a salary or commission, for the simple reason that it offered an accounting convenience. Never have they relinquished their professional rights as physicians and never have they agreed that they are performing a hospital service instead of a medical service.

Regardless of the fiscal arrangement under which a radiologist practises his profession in the hospital, he denies the hospital a right to profit from his practice or to sell his services on an annual premium basis to groups of insurance subscribers. The hospital is entitled to retain a portion of radiologic fees sufficient to repay it for its costs in maintaining a department where patients can be treated and where the doctor may treat them, but it has no moral, legal, or ethical right to demand a net profit from professional services rendered by members of the staff in the hospital.

The issue is clear. It should be discussed dispassionately and attempts at settlement should always be made in a spirit of friendly co-operation. Physicians and hospitals must work together; neither can get along without the other. That the difficulties here discussed can be settled to the mutual advantage of physician and hospital and to the advantage of the public has been repeatedly proven by experience in many localities throughout the nation.

MAC F. CAHAL
Executive Secretary

RADIOLOGICAL SOCIETIES IN THE UNITED STATES

Editor's Note—Will secretaries of societies please cooperate with the Editor by supplying him with information for this section? Please send such information to Leon J. Menville, M.D., 1201 Maison Blanche Bldg., New Orleans, La.

CALIFORNIA

California Medical Association, Section on Radiology.—Chairman, John D. Lawson, M.D., 1306 California State Bldg., Sacramento; *Secretary,* Karl M. Bonoff, M.D., 1930 Wilshire Blvd., Los Angeles. Meets annually with California Medical Association.

Los Angeles County Medical Association, Radiological Section.—President, John F. Chapman, M.D., 65 N. Madison Ave., Pasadena; *Vice-president,* E. N. Liljedahl, M.D., 1241 Shatto St.; *Secretary,* Merl L. Pindell, M.D., 678 South Ferris Ave. *Treasurer,* Henry Snure, M.D., 1414 Hope Street. Meets every second Wednesday of month at County Society Building.

Pacific Roentgen Club.—At its recent Annual Meeting at Pasadena, the following officers were elected for the ensuing year: *Chairman,* Lyell C. Kinney, M.D., San Diego; *Member of the Executive Committee,* Irving S. Ingber, M.D., San Francisco; *Secretary-Treasurer,* L. Henry Garland, M.D., Suite 1739, 450 Sutter Street, San Francisco. The other members of the Executive Committee are: Lowell S. Goin, M.D., Los Angeles, and Alfred C. Siefert, M.D., Oakland.

San Francisco Radiological Society.—Secretary, L. H. Garland, M.D., 450 Sutter Street. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

COLORADO

Denver Radiological Club.—President, John S. Bouslog, M.D., 246 Metropolitan Bldg.; *Vice-president,* Sanford Withers, M.D., 304 Republic Bldg.; *Secretary,* Ernst A. Schmidt, M.D., Colorado General Hospital; *Treasurer,* H. P Brandenburg, M.D., 155 Metropolitan Bldg. Meets third Tuesday of each month at homes of members.

CONNECTICUT

Connecticut State Medical Society, Section on Radiology.—Chairman, Ralph T. Ogden, M.D., 179 Allyn St., Hartford; *Vice-chairman,* Francis M. Dunn, M.D., 100 State Street, New London; *Secretary-Treasurer,* Max Climan, M.D., 242 Trumbull St., Hartford. Meetings twice annually in May and September.

DELAWARE

Affiliated with Philadelphia Roentgen Ray Society.

FLORIDA

Florida State Radiological Society.—President, H. O. Brown, M.D., 404 First National Bank Bldg., Tampa; *Vice-president,* H. B. McEuen, M.D., 126 W. Adams St., Jacksonville; *Secretary-Treasurer,* J. H. Lucinian, M.D., 168 S. E. 1st St., Miami.

GEORGIA

Georgia Radiological Society.—President, James J. Clark, M.D., Doctors Bldg., Atlanta; *Vice-president,* William F. Lake, M.D., Medical Arts Bldg., Atlanta; *Secretary-Treasurer,* Robert C. Pendergrass, M.D., Prather Clinic, Americus. Meetings twice annually, in November and at the annual meeting of the Medical Association of Georgia in the spring.

ILLINOIS

Chicago Roentgen Society.—President, David S. Beilin, M.D., 411 Garfield Ave.; *Vice-president,* Chester J. Challenger, M.D., 3117 Logan Blvd.; *Secretary-Treasurer,* Roe J. Maier, M.D., 7752 Halsted St. Meets second Thursday of each month, September to May, except December.

Illinois Radiological Society.—President, Cesare Gianturco, M.D., 602 W. University Ave., Urbana; *Vice-president,* Fred H. Decker, M.D., 802 Peoria Life Bldg., Peoria; *Secretary-Treasurer,* Edmund P. Halley, M.D., 968 Citizens Bldg., Decatur. Meetings quarterly by announcement.

Illinois State Medical Society, Section of Radiology.—President, Roswell T. Pettit, M.D., 728 Columbus St., Ottawa; *Secretary,* Ralph G. Willy, M.D., 1138 N. Leavitt St., Chicago.

INDIANA

Indiana Roentgen Society.—President, Stanley Clark, M.D., 108 N. Main St., South Bend; *President-elect,* Juan Rodriguez, M.D., 2903 Fairfield Ave., Fort Wayne; *Vice-president,* A. C. Holley, M.D., Attica; *Secretary-Treasurer,* Clifford C. Taylor, M.D., 23 E. Ohio St., Indianapolis. Annual meeting in May.

IOWA

The Iowa X-ray Club.—Holds luncheon and business meeting during annual session of Iowa State Medical Society.

MAINE

See New England Roentgen Ray Society.

MARYLAND

Baltimore City Medical Society, Radiological Section.—Chairman, Marcus Ostro, M.D., 1810 Eutaw Place; *Secretary,* H. E. Wright, M.D., 101 W Read St., Baltimore. Meetings second Tuesday of each month.

MASSACHUSETTS

See New England Roentgen Ray Society.

MICHIGAN

Detroit X-ray and Radium Society.—President, E. W. Hall, M.D., 10 Peterboro Street; *Vice-president,*

Sam W. Donaldson, M.D., 326 North Ingalls St., Ann Arbor; *Secretary-Treasurer*, E. R. Witwer, M.D., Harper Hospital. Meetings first Thursday of each month from October to May, inclusive, at Wayne County Medical Society Bldg.

Michigan Association of Roentgenologists.—President, E. R. Witwer, M.D., Harper Hospital, Detroit; *Vice-president*, D. W. Patterson, M.D., 622 Huron Street, Port Huron; *Secretary-Treasurer*, C. K. Hasley, M.D., 1429 David Whitney Bldg., Detroit.

MINNESOTA

Minnesota Radiological Society.—President, Walter H. Ude, M.D., 78 S. 9th St., Minneapolis; *Vice-president*, Leo G. Rigler, M.D., University Hospitals, Minneapolis; *Secretary-Treasurer*, Harry Weber, M.D., 102 Second Ave., S. W., Rochester. Meetings quarterly.

MISSOURI

The Kansas City Radiological Society.—President, L. G. Allen, M.D., 907 N. 7th St., Kansas City, Mo.; *Secretary*, Ira H. Lockwood, M.D., 306 E. 12th St., Kansas City, Mo. Meetings last Thursday of each month.

The St. Louis Society of Radiologists.—President, Joseph C. Peden, M.D., 634 N. Grand Blvd.; *Secretary*, W. K. Mueller, M.D., 607 N. Grand Blvd. Meetings fourth Wednesday of each month.

NEBRASKA

Nebraska Radiological Society.—President, E. W. Rowe, M.D., 128 N. 13th St., Lincoln; *Secretary*, D. Arnold Dowell, M.D., 117 S. 17th St., Omaha. Meetings first Wednesday of each month at 6 P.M. in Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY

(Maine, New Hampshire, Vermont, Massachusetts, and Rhode Island.) *President*, Frank E. Wheatley, M.D., 520 Beacon St., Boston; *Secretary*, E. C. Vogt, M.D., 300 Longwood Ave., Boston. Meetings third Friday of each month from October to May, inclusive, usually at Boston Medical Library.

NEW HAMPSHIRE

See New England Roentgen Ray Society.

NEW JERSEY

Radiological Society of New Jersey.—President, Milton Friedman, M.D., Newark Beth Israel Hospital, Newark; *Vice-president*, P. S. Avery, M.D., 546 Central Ave., Bound Brook; *Secretary*, W. James Marquis, M.D., 198 Clinton Ave., Newark; *Treasurer*, James Boyes, M.D., 744 Watchung Ave., Plainfield. Meetings at Atlantic City at time of State Medical Society, and Midwinter in Newark as called by president.

NEW YORK

Brooklyn Roentgen Society.—President, Albert Voltz, M.D., 115–120 Myrtle Avenue, Richmond Hill; *Vice-president*, A. L. L. Bell, M.D., Long Island College Hospital, Henry, Pacific, and Amity Sts., Brooklyn; *Secretary-Treasurer*, E. Mendelson, M.D., 132 Parkside Ave., Brooklyn. Meetings first Tuesday in each month at place designated by president.

Buffalo Radiological Society.—President, Walter Mattick, M.D., 101 High St.; *Vice-president*, Chester Moses, M.D., 333 Linwood Ave.; *Secretary-Treasurer*, J. S. Gian-Franceschi, M.D., 610 Niagara Street. Meetings second Monday evening each month.

Central New York Roentgen-ray Society.—President, W. E. Achilles, M.D., 60 Seneca St., Geneva; *Vice-president*, M. T. Powers, M.D., 250 Genesee St., Utica; *Secretary-Treasurer*, Carlton F. Potter, M.D., 425 Waverly Ave., Syracuse. Meetings held in January, May, and October as called by Executive Committee.

Long Island Radiological Society.—President, Samuel G. Schenck, M.D., Brooklyn; *Vice-president*, G. Henry Koiransky, M.D., Long Island City; *Secretary*, Marcus Wiener, M.D., 1430 48th St., Brooklyn; *Treasurer*, Louis Goldfarb, M.D., 608 Ocean Ave., Brooklyn. Meetings fourth Thursday evening each month at Kings County Medical Bldg.

New York Roentgen Society.—President, Raymond W. Lewis, M.D., 321 E. 42nd St., New York City; *Vice-president*, Henry K. Taylor, M.D., 667 Madison Ave., New York City; *Secretary*, Roy D. Duckworth, M.D., 170 Maple Ave., White Plains; *Treasurer*, Eric J. Ryan, M.D., St. Luke's Hospital, New York City; *Member of Executive Committee*, E. Forrest Merrill, M.D., 30 W. 59th St., New York City. Meetings third Monday evening each month at Academy of Medicine.

Rochester Roentgen-ray Society.—Chairman, Joseph H. Green, M.D., 277 Alexander St.; *Secretary*, S. C. Davidson, M.D., 277 Alexander St. Meetings at convenience of committee.

Society of Radiological Economics of New York.—President, Albert L. Voltz, M.D., 115–120 Myrtle Ave., Richmond Hill; *Vice-president*, M. M. Pomeranz, M.D., 911 Park Ave., New York City; *Secretary*, W. F. Francis, M.D.; *Treasurer*, Theodore West, M.D., United Hospital, Port Chester. Meetings first Monday evening each month at McAlpin Hotel.

NORTH CAROLINA

Radiological Society of North Carolina.—President, Robert P. Noble, M.D., 127 W. Hargett St., Raleigh; *Vice-president*, A. L. Daughtridge, M.D., 144 Coast Line St., Rocky Mount; *Secretary-Treasurer*, Major I. Fleming, M.D., 404 Falls Road, Rocky Mount. Meetings with State meeting in May, and meeting in October.

OHIO

Cleveland Radiological Society.—President, North W. Shetter, M.D., Lakewood City Hospital, Lakewood: *Vice-president,* John Heberding, M.D., St. Elizabeth's Hospital, Youngstown; *Secretary-Treasurer,* Harry Hauser, M.D., Cleveland City Hospital, Cleveland. Meetings at 6:30 P.M. at Cleveland Chamber of Commerce Club on fourth Monday of each month from October to April, inclusive.

Radiological Society of the Academy of Medicine (Cincinnati Roentgenologists).—*President,* B. M. Warne, M.D., Doctors Building, Cincinnati; *Secretary-Treasurer,* Justin E. McCarthy, M.D., 707 Race St., Cincinnati, Ohio. Meetings held third Tuesday of each month.

PENNSYLVANIA

Pennsylvania Radiological Society.—President, Charles S. Caldwell, M.D., 520 S. Aiken, Ave., Pittsburgh; *First Vice-president,* Thomas L. Smyth, M.D., 111 N. 8th St., Allentown; *Second Vice-president,* Reuben G. Alley, M.D., Western Pennsylvania Hospital, Pittsburgh; *Secretary-Treasurer,* Lloyd E. Wurster, M.D., 416 Pine St., Williamsport; *President-elect,* Louis A. Milkman, M.D., 212 Medical Arts Bldg., Scranton; *Editor,* William E. Reiley, M.D., Clearfield. Annual meeting, May, 1939. Exact date and place to be decided.

Philadelphia Roentgen Ray Society.—President, Thomas P. Laughery, M.D., Germantown Hospital; *Vice-president,* Elwood E. Downs, M.D., Jeans Hospital, Fox Chase; *Secretary,* Barton H. Young, M.D., Temple University Hospital; *Treasurer,* R. Manges Smith, M.D., Jefferson Hospital. Meetings first Thursday of each month from October to May, Thompson Hall, College of Physicians, 19 S. 22nd St., 8:15 P.M.

The Pittsburgh Roentgen Society.—President, William B. Ray, M.D., 320 E. North Avenue, N. S. Pittsburgh; *Secretary,* Harold W. Jacox, M.D., 4800 Friendship Ave. Meetings held second Wednesday of each month at 4:30 P.M., from October to June at various hospitals designated by program committee.

RHODE ISLAND

See New England Roentgen Ray Society.

SOUTH CAROLINA

South Carolina X-ray Society.—President, Robert B. Taft, M.D., 105 Rutledge Ave., Charleston; *Secretary-Treasurer,* Hillyer Rudisill, M.D., Roper Hospital, Charleston. Meetings in Charleston on first Thursday in November, also at time and place of South Carolina State Medical Association.

SOUTH DAKOTA

Meets with Minnesota Radiological Society

TENNESSEE

Memphis Roentgen Club.—Chairmanship rotates monthly in alphabetical order. Meetings second Tuesday of each month at University Center.

Tennessee State Radiological Society.—President, S. S. Marchbanks, M.D., 508 Medical Arts Bldg., Chattanooga; *Vice-president,* Steve W. Coley, M.D., Methodist Hospital, Memphis; *Secretary-Treasurer,* Franklin B. Bogart, M.D., 311 Medical Arts Bldg., Chattanooga. Meeting annually with State Medical Society in April.

TEXAS

Texas Radiological Society.—President, R. G. Giles, M.D., Medical Arts Bldg., San Antonio; *President-elect,* Jerome H. Smith, M.D., Shannon West Texas Memorial Hospital, San Angelo; *First Vice-president,* C. F. Crain, M.D., 416 Chaparral St., Corpus Christi; *Second Vice-president,* M. H. Glover, M.D., 904 8th St., Wichita Falls; *Secretary-Treasurer,* G. D. Carlson M.D., 3121 Bryan St., Dallas. Meets annually. San Antonio is place of meeting, Oct. 22, 1938.

VERMONT

See New England Roentgen Ray Society.

VIRGINIA

Radiological Society of Virginia.—President, Fred M. Hodges, M.D., 100 W. Franklin St., Richmond; *Vice-president,* L. F. Magruder, M.D., Raleigh and College Aves., Norfolk; *Secretary,* V. W. Archer, M.D., University of Virginia Hospital, Charlottesville.

WASHINGTON

Washington State Radiological Society.—President, H. E. Nichols, M.D., Stimson Bldg., Seattle; *Secretary,* T. T. Dawson, M.D., Fourth and Pike Bldg., Seattle. Meetings fourth Monday of each month at College Club.

WISCONSIN

Milwaukee Roentgen Ray Society.—Secretary, S. A. Morton, M.D., Columbia Hospital, Milwaukee. Meets monthly on first Friday.

Radiological Section of the Wisconsin State Medical Society.—Secretary, Russel F. Wilson, M.D., Beloit Municipal Hospital, Beloit. Two-day annual meeting in May and one day in connection with annual meeting of State Medical Society, in September.

University of Wisconsin Radiological Conference.—Secretary, E. A. Pohle, M.D., 1300 University Ave., Madison, Wis. Meets every Thursday from 4 to 5 P.M., Room 301, Service Memorial Institute.

EDITORIAL

LEON J. MENVILLE, M.D., *Editor* HOWARD P. DOUB, M.D., *Associate Editor*

AN OPPORTUNITY FOR ROENTGENOLOGY

The avowed intention of many endowments is to achieve some advancement in knowledge that will bring benefit to humanity. Men of experience realize the shortcomings of prevalent methods and decide to devote their money and their efforts to correction of faults apparent to them. Again, some personal experience magnifies the inadequacies of existing knowledge in some specific instance and persons of means are brought to realize the possibilities of benefit inherent in research and they decide to devote their wealth to support of the efforts of trained workers, under proper supervision, toward the development of new facts and new practical experiences along these lines. The participation of established governmental services in many phases of research and practice seems to offer an opportunity which merits attention.

Even men of wide experience encounter some forms of disease so rarely that constant review of the available literature is necessary to recognition of these diseases when they present themselves. This is particularly true in roentgenology. Practical experience has demonstrated that there is a woeful lack of knowledge of the roentgenographic image of even some of the more common lesions in which the roentgenographic image is all but pathognomonic. Occasionally cases are encountered in which amputation or another drastic surgical procedure has been advised for a benign lesion and occasionally, with the best intentions but erroneously, therapeutic measures have been instituted which were not only useless but in some cases were opposed to the best interests of the patient. Heretofore these errors were discovered only at necropsy, or by study of tissue after surgical procedures had been carried out. With the advent of the roentgenogram and its factual evidence, many of these catastrophies have been averted.

Knowledge of the roentgenographic image comes from visualization. The fault of most of the roentgenologic literature is its paucity of illustrations. The plea of the earnest student of roentgenology is for opportunity to study the roentgenographic image at the time of his reading of the literature. When this can be accomplished, roentgenology will rise to even greater heights than it has attained and will continue to be more and more respected as a diagnostic procedure. The opportunity to achieve this association of reading and illustration lies in the development of photography as an adjunct. The reduction of all manner of records, newspapers, magazines, books and so forth to 16 and 35 mm. film for the conservation of space is an accomplished fact. Provision has been made for the projection of these miniature copies under conditions that make review of them convenient, pleasant, and satisfactory in every sense.

The time seems opportune to suggest the establishment of a film library in the National Capitol, as an integral part of the Army Medical Library. With minimal requirement of space, a thoroughly comprehensive library of film studies, with the necessary apparatus for projection of them in an enlarged image, could be situated so that the literature could be consulted at the time of review of the films.

If the success of the initial experiment warranted, at small additional expense branch libraries could be established at convenient centers throughout the nation, preferably in the libraries of universities, by reproducing the master films and distributing these after they had been properly edited and legends had been written. Under proper auspices, there is no doubt that the leading institutions of the country would co-operate in allowing a survey of their material and reproduction of that chosen as suitable for incorporation in a national institution.

I believe such an object is worthy of the best

efforts of the roentgenologists as a group. Its accomplishment would mean a great deal to the men of lesser opportunity in our profession who are earnestly striving to better their knowledge of the science of roentgenology and it would serve to heighten materially the value of roentgenology as a diagnostic procedure.

CHARLES G. SUTHERLAND, M.D.

ANNUAL MEETING, NOV. 28—DEC. 2, 1938

YOU'LL BE SURPRISED AT PITTSBURGH!

Have you ever really seen Pittsburgh? Are you one of the visitors who smilingly refers to the "smoky city," or have you ever seriously considered the greatness that is truly ours? While you are here we want you to take time to see our city and a few of our many unusual attractions. We promise you that you'll not be sorry. You will be surprised!

Let us take you for a brief trip to just a few of the many fascinating places our city offers to every visitor. We'll start at the lower end of the triangle in the downtown section and visit the famous Block House, located almost at the Point, where the Allegheny and Monongahela rivers join to form the mighty Ohio. And, rich in the historical lore of our great country, here stands an old brick building—all that remains of Fort Pitt.

Leaving the Block House, we drive through the Golden Triangle, one of the richest business centers in the world and the location of the home and branch offices of internationally prominent business organizations. At the outer edge of the triangle we drive up the Boulevard of the Allies, dedicated at the close of the World War and named accordingly. Travelling right on a ramp, we cross the famous Liberty Bridge and enter the Liberty Tubes, second largest vehicular tunnels in the world. After a brief trip through some of the most beautiful residential districts you will ever see, we return through the tubes to the boulevard and drive on to Schenley Park, which is only one of the twenty parks located in Pittsburgh. Leaving the park we arrive at Phipps Conservatory, the largest of its kind in the world, and something you should not miss while you are here. In this huge glass house you will find a veritable fairyland of beauty.

At this point we believe the visitor will lift an eyebrow at this new and unknown approach to a city which for so many years has retained its prominence through an industrial background alone. But, now comes the real surprise: Leaving the Phipps Conservatory we approach the great Civic Center of the Oak'and district, a collection of buildings and institutions which we think you will agree is unexcelled in any city in America. Our first view, of course, will be the magnificent "Cathedral of Learning," forty-two stories of schoolhouse, Gothic in architecture. You will be amazed at its beauty, inside and out. On the Forbes Street side of the great Cathedral will be found the Stephen Collins Foster Memorial, which contains the original manuscripts of this great writer of American folk songs, and stands for all to see as the costliest and finest tribute ever built to the memory of any musician. To the right of the Cathedral stands the Heinz Memorial Chapel, a religious inspiration.

Across the street from the Cathedral stands the great Carnegie Museum and Library. Whole days might be spent inspecting the unusual collections and museum pieces in these great buildings. Here, too, can be found the Carnegie Institute, always with an art exhibition of outstanding interest, and here in the winter of each year hangs the only Annual International Art Exhibit in the world. Leaving the museum and art institute, we cross the street again to the magnificent building of the Board of Education, past the Y. M. H. A. Building, and again we feel sure our visitors will gasp at the beauty and immensity, combined with graceful proportions of the Mellon Institute of Industrial Research. Here in this great "Temple of Science," which truly appears as a Greek temple, are conducted experiments which are aimed at easing man's burden. You will find experiments being conducted here at which you will marvel and thrill.

We are stopping now to leave the remainder of the inspection of our city to your own devices. We feel that you have seen a part of our Pittsburgh you didn't know. There are many more things which you will find of the keenest interest, and we hope that we have created a desire for you to come to Pittsburgh and be surprised!

PRELIMINARY PROGRAM

SCIENTIFIC PROGRAM
of the
RADIOLOGICAL SOCIETY
OF NORTH AMERICA

November 28–December 2, 1938

Hotel William Penn, Pittsburgh, Penna.

Monday Morning, Nov. 28, 1938
Urban Ball Room

10:30 A.M.

Call to order.....HOWARD P. DOUB, M.D.
President of the Radiological Society of North America

SCIENTIFIC SESSION

"The Bone Changes in Primary Hypogonadism." L. M. HURXTHAL, M.D., Boston, Mass. (by invitation), and HUGH HARE, M.D., Boston, Mass.

"Bone Changes in Generalized Lipoid Diseases." MARCY L. SUSSMAN, M.S., M.D., Mount Sinai Hospital, New York City (by invitation). and L. JACHES, M.D., Mount Sinai Hospital, New York City.

"Osteogenesis Imperfecta Tarda." J. FLETCHER LUTZ, M.D., Department of Radiology and Pathology, York Hospital, York, Penna., and LEWIS C. PUSCH, M.D., Department of Radiology and Pathology, York Hospital, York, Penna. (by invitation).

Monday Afternoon

2:00 P.M. Diagnostic Symposium, Section A, *Urban Ball Room*

Symposium on Gastro-intestinal Diseases, arranged by JOSEPH C. BELL, M.D., Louisville, Kentucky

"Experiences with the Compression Technic in Gastro-intestinal Examinations." ROSS M. GOLDEN, M.D., New York City, and PAUL SWENSON, M.D., New York City.

"Some Examples of the Use of Compression Technic in the Diagnosis of Diseases of the Upper Gastro-intestinal Tract." JOSEPH C. BELL, M.D., Louisville, Ky.

"The Roentgen-ray Diagnosis of Some Lesions of the Fundus of the Stomach." ALEXANDER B. MOORE, M.D., Washington, D. C.

"The Roentgenologic Diagnosis of Lesions of the Sigmoid and Rectosigmoid." HARRY M. WEBER, M.D., Mayo Clinic, Rochester, Minn.

2:00 P.M. Therapeutic Symposium, Section B, *Cardinal Room*

Symposium on Carcinoma of the Breast, arranged by ROLLIN H. STEVENS, M.D., Detroit, Mich.

"Evaluation of Roentgenographic Findings in the Diagnosis of Mammary Diseases." HOWARD B. HUNT, M.D., N. F. HICKEN, M.D., and T. T. HARRIS, M.D., Department of Radiology, College of Medicine, University of Nebraska, Omaha, Nebr. To be presented by Dr. Hunt.

"Carcinoma of the Breast, with Consideration of Whole Organ Section Studies." EUGENE R. WHITMORE, M.D., Department of Radiology and Pathology, Gallinger Hospital, Washington, D. C. (by invitation).

"The Relation of Ovarian Hormones to Benign Breast Hyperplasia and Neoplasia." MILTON FRIEDMAN, M.D., New York City.

"Pre-operative Treatment of Carcinoma of the Breast." FRANK E. ADAIR, M.D., Memorial Hospital, New York City (by invitation).

"Hormonal Relations of the Human Breast." CHARLES F. GESCHICKTER, M.D., Baltimore, Md. (by invitation).

4:30 P.M. Clinics.

Monday Evening

7:00 P.M. Counselors' Dinner, *Urban Ball Room*

Tuesday Morning, Nov. 29, 1938
Urban Ball Room

9:00 A.M.

"Professional Standards in Radiology." LOWELL S. GOIN, M.D., Los Angeles, Calif.

"Practical Roentgen Pelvimetry." ALBERT M. MALONEY, M.D., Boston, Mass. (by invitation).

"The Roentgen Kymogram of the Heart as a Complete Record." I. SETH HIRSCH, M.D., New York City.

"The Pulmonary Arteries: A Roentgenographic and Roentgen Kymographic Study." SAMUEL BROWN, M.D., Cincinnati, Ohio; JUSTIN E. MCCARTHY, M.D., Cincinnati, Ohio, and ARCHIE FINE, M.D., Cincinnati, Ohio (by invitation).

"Roentgen Diagnosis of the Strawberry Gallbladder." GEORGE LEVENE, M.D.,

Mass. Memorial Hospitals, Boston, ROBERT M. LOWMAN, M.D., Mass. Memorial Hospitals, Boston. (by invitation), and EGON G. WISSING, M.D., Mass. Memorial Hospitals, Boston, Mass. (by invitation).

"The Value of Roentgen Examination of the Paranasal Sinuses." VINCENT C. JOHNSON, M.D., University of Michigan, Ann Arbor, Mich. (by invitation).

"The Golden Triangle," the billion-dollar business district of Pittsburgh. Here are located the home offices of some of the world's largest business and industrial concerns.

Tuesday Afternoon

2:00 P.M.

EXECUTIVE SESSION

Urban Ball Room

3:00 P.M. Diagnostic Symposium, Section A, *Urban Ball Room*

Symposium on Pulmonary Diseases, arranged by JOHN T. FARRELL, JR., M.D., Philadelphia, Penna.

"Group X-ray Surveys of Apparently Healthy Individuals." DAVID E. EHRLICH, M.D., New York City, and ARTHUR B. ROBINS, M.D., New York City (by invitation).

"Tuberculosis of the Lower Lobes." MARTIN J. SOKOLOFF, M.D., Philadelphia, Penna. (by invitation).

"Comparative Study of Roentgen and Postmortem Findings in Diseases of the Lungs." JOHN T. FARRELL, JR., M.D., Philadelphia, Penna.

2:00 P.M. Therapeutic Symposium, Section B, *Cardinal Room*

Symposium on Cancer of the Cervix, arranged by EDWIN C. ERNST, M.D., St. Louis, Mo.

"Roentgen Therapy." EDWIN C. ERNST, M.D., St. Louis, Mo.

"Radium Therapy." AXEL NORMAN ARNESON, M.D., St. Louis, Mo.

"Clinico-pathological Considerations." WILLIAM P. HEALY, M.D., Memorial Hospital, New York City (by invitation).

4:30 P.M. Clinics.

Tuesday Evening

CARMAN LECTURE

Urban Ball Room

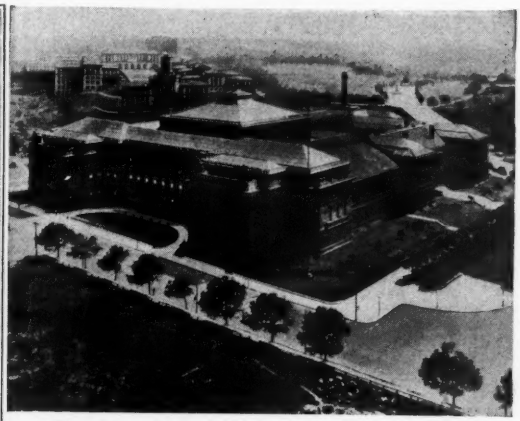
8:30 P.M.

Wednesday Morning, Nov. 30, 1938
Urban Ball Room

9:00 A.M.

"The Occurrence of Two or More Primary Malignant Lesions." JOHN J. COLLINS, M.D.,

"Cathedral of Learning," main building of the University of Pittsburgh, The world's only skyscraper schoolhouse.



The Carnegie Institute, showing Carnegie Institute of Technology in the left background, located in Schenley Park. It comprises a department of fine arts, a museum of natural history, and a music hall.

The John D. Archbold Memorial Hospital, Thomasville, Ga.

"Hyperthyroidism with Other of the Ductless Glands as Trigger Mechanisms." WARNER JENKINS, M.D., Waco, Texas (by invitation).

"The Treatment of Acute and Chronic Inflammatory Conditions by Fractional Doses of X-ray." HERMAN A. OSGOOD, M.D., Boston, Mass. (by invitation).

"Recovery Following Human Ovarian Irradiation." HAROLD W. JACOX, M.D., The Western Pennsylvania Hospital, Pittsburgh, Penna.

"Roentgen Therapy of Cancer by the Contact or Short-distance Method." GEORGE T. PACK, M.D., New York City; JAMES S. GALLO, M.D., New York City (by invitation), and BOYD E. WILKINSON, M.D., Paterson, N. J.

"Some Experiences, Experimental and Clinical, with Direct Irradiation of Neurological Tumors, at Operation with Low Voltage Radiation: A Preliminary Report." JOHN RUSSELL CARTY, M.D., New York Hospital, New York City, and BRONSON S. RAY, Assistant Attending Surgeon, New York Hospital, New York City (by invitation).

Wednesday Afternoon

2:00 P.M. Diagnostic Symposium, Section A, *Urban Ball Room*

Symposium on Low Back and Sciatic Pain, arranged by JOHN D. CAMP, M.D., Mayo Clinic, Rochester, Minn.

"Clinical and Neurologic Aspects." M. N. WALSH, M.D., Mayo Clinic, Rochester, Minn. (by invitation).

"Orthopedic Aspects." PAUL B. STEELE, M.D., Pittsburgh, Penna. (by invitation).

"Significant Skeletal Changes (Roentgenologic Observations)." RALPH S. BROMER, M.D., Bryn Mawr, Penna.

"Air Myelography: The Use of Air as the Contrast Medium in Roentgen Exploration of the Spinal Canal." W. EDWARD CHAMBERLAIN, M.D., Philadelphia, Penna., and BARTON R. YOUNG, M.D., Philadelphia, Penna. (by invitation).

"Experiences with Lipiodol in the Localization of Lesions Associated with Low Back and Sciatic Pain." JOHN D. CAMP, M.D., Mayo Clinic, Rochester, Minn.

2:00 P.M. Therapeutic Symposium, Section B, *Cardinal Room*

Symposium on Radiotherapy for Inflammatory Conditions, arranged by ARTHUR U. DESJARDINS, M.D., Mayo Clinic (Section on Therapeutic Radiology), Rochester, Minn.

"Acute Otitis Media." ANDREW H. DOWDY, M.D., Strong Memorial Hospital, Rochester, N. Y. (by invitation), and CLYDE HEATLY, M.D., Strong Memorial Hospital, Rochester, N. Y. (by invitation).

"The Roentgen Therapy of Carefully Selected Sinus Infections." FRED M. HODGES, M.D., Richmond, Va., and L. O. SNEAD, M.D., Richmond, Va. (by invitation).

"The Use of the Mobile X-ray Unit in the Treatment of Peritonitis, Gas Gangrene, and Other Inflammatory Processes at the Bedside." JAMES F. KELLY, M.D., Omaha, Nebr.

"Further Experiences with Roentgen Therapy for Bronchiectasis." MAURICE BERCK, M.D., New York City (by invitation), and WILLIAM HARRIS, M.D., New York City.

"Roentgen Therapy for Chronic Infectious Arthritis." ARTHUR U. DESJARDINS, M.D., Mayo Clinic, Rochester, Minn.

4:30 P.M. Clinics.

Thursday Morning, Dec. 1, 1938
Urban Ball Room

9:00 A.M.

"A Roentgenologic Consideration of Gastritis." MAURICE FELDMAN, M.D., Assistant Professor of Gastro-enterology, University of Maryland, Baltimore, Md.

"Chronic Gastric Volvulus." ARTHUR C. SINGLETON, M.D., Toronto, Ontario, Canada.

"Benign Duodeno-colic Fistula, with Report of Two Cases." CLARENCE N. MCPEAK, M.D., Fitchburg, Mass. (by invitation).

"Polyps of the Large Bowel." EDWARD L. JENKINSON, M.D., St. Luke's Hospital, Chicago, Ill., and WILLIAM WASKOW, M.D., St. Luke's Hospital, Chicago, Ill. (by invitation).

"The Incidence of Duodenal Ulcer in the Presence of a Gall-bladder Symptomatology." ERIC J. RYAN, M.D., St. Luke's Hospital, New York City.

"Roentgenological Differential Diagnosis between Diverticulitis and Cancer of the Colon." RICHARD SCHATZKI, M.D., Massachusetts General Hospital, Boston, Mass.

Thursday Afternoon

2:00 P.M.

EXECUTIVE SESSION

Urban Ball Room

3:00 P.M. Diagnostic Symposium, Section A, *Urban Ball Room*

Symposium on Body Section Radiography, arranged by SHERWOOD MOORE, M.D., St. Louis, Mo.

"Analysis of the Various Motions Suitable for Body Section Radiography." MR. JEAN KIEFFER, Supervisor of Laboratories, Norwich State Tuberculosis Sanatorium, Norwich, Conn. (by invitation).

"Sectional Roentgenography: Its Application to the Upper Respiratory Tract." WILLIAM E. HOWES, M.D., Brooklyn, N. Y.

"Exploration of the Thorax with Body Section Roentgenography." HUGH M. WILSON, M.D., Associate Professor of Radiology, Yale University School of Medicine, New Haven, Conn. (by invitation).

"Body Section Radiography." SHERWOOD MOORE, M.D., Professor of Radiology, Washington University School of Medicine and Director of the Edward Mallinckrodt Institute of Radiology, St. Louis, Mo.

2:00 P.M. Therapeutic Symposium, Section B, *Cardinal Room*

Symposium on The Treatment of Carcinoma of the Pharynx and Larynx, arranged by L. HENRY GARLAND, M.D., San Francisco, Calif.

"Present Conception of Treatment of Carcinoma of the Larynx." HENRI COUTARD, M.D., Chicago (by invitation).

"Surgical Treatment of Cancer of the Larynx." J. HOMER MCCREADY, M.D., Pittsburgh, Penna. (by invitation).

"Technic and Complications of Treatment of Carcinoma of the Pharynx." HAYES E. MARTIN, M.D., New York City.

4:30 P.M. Clinics.

7:00 P.M.

BANQUET

Urban Ball Room

Friday Morning, Dec. 2, 1938
Urban Ball Room

9:00 A.M.

"The Density of the Central Shadow of the Thorax in the Diagnosis of Intrathoracic Lesions." LEO G. RIGLER, M.D., Minneapolis, Minn.

"Pulmonary Involvement in the Lymphoblastomas: Special Reference to Roentgen Aspects." ADOLPH HARTUNG, M.D., University of Illinois, Chicago.

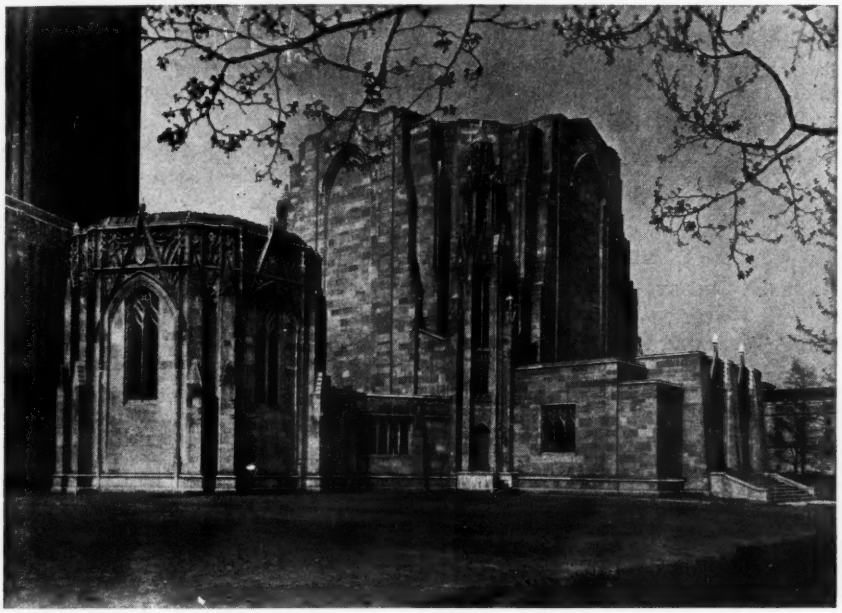
"X-ray Intensity Meter." ROBERT B. TAFT, M.D., Charleston, S. C.

"Problems in Roentgen Diagnosis of Pulmonary Tuberculosis." CARL C. BIRKELO, M.D., Detroit, Mich., and W. L. BROSIUS, M.D., Herman Kiefer Hospital, Detroit, Mich. (by invitation).

Symposium on Industrial Diseases, arranged by ELDWIN R. WITWER, M.D., Detroit, Mich.

(*Tentative Titles*)

"Silicosis." EUGENE P. PENDERGRASS, M.D., Philadelphia, Penna.



Stephen Collins Foster Memorial Theater and Shrine, finest building ever dedicated to a musician; a fitting tribute honoring "America's Troubadour," born at Pittsburgh July 4, 1826.

"Castration of the Female by Irradiation: The Results in 335 Patients":

Part A, "An Efficient Radiological Technic." WILLIS S. PECK, M.D., and JOHN T. MCGREER, M.D., Department of Roentgenology, University of Michigan, Ann Arbor, Mich. (by invitation).

Part B, "Menopausal Symptoms." NORMAN KRETZCHMAR, M.D., and WILLIS BROWN, M.D., Department of Gynecology and Obstetrics, University of Michigan, Ann Arbor, Mich. (by invitation).

"Recent Advances in Nuclear Physics." DR. E. V. CONDON, Westinghouse Research Company, East Pittsburgh, Penna. (by invitation).

Friday Afternoon

2:00 P.M. Diagnostic Symposium, Section A, *Urban Ball Room*

"Silico-tuberculosis." BRUCE DOUGLAS, M.D., Detroit, Mich. (by invitation).

"Asbestosis." RALPH D. LEONARD, M.D., Boston, Mass. (by invitation).

"The Influence of Gases on Pulmonary Tissues." DR. E. E. EVANS, DuPont Film Corporation, New York City (by invitation).

2:00 P.M. Therapeutic Symposium, Section B, *Cardinal Room*

Symposium on What are the Differences Between 200 kv. and Supervoltage Roentgentherapy, arranged by U. V. PORTMANN, M.D., Cleveland Clinic Foundation, Cleveland O.

"The Physical Aspects." RICHARD DRESSER, M.D., and Associates, Boston, Mass., and KENNETH E. CORRIGAN, PH.D., Detroit, Mich. (by invitation).

"The Biological Aspects." CHARLES

PACKARD, M.D., New York City (by invitation).

"The Chemical Aspects." WILLIAM E. COSTOLOW, M.D., Los Angeles, Calif., and HENRY SCHMITZ, M.D., Chicago.

CLINICS

To be held afternoons, except Friday, from four-thirty to five-thirty o'clock.

AUTHORS	TITLES
SHERWOOD MOORE, M.D.	"Body Section Radiography"
JOHN D. CAMP, M.D.	"The Use of Iodized Oil in the Location of Lesions within the Spinal Canal"
EUGENE P. PENDERGRASS, M.D.	"Silicosis"
JOSEPH C. BELL, M.D.	"The Use of the Spot Film in the Diagnosis of Lesions of the Gastro-intestinal Tract and Gall Bladder"
JOHN R. CARTY, M.D.	"Diagnostic Possibilities of Radiography of the Soft Tissues"
MRS. EDITH H. QUIMBY	"Specification of Tissue Dosage in Radiotherapy"
BERNARD P. WIDMANN, M.D.	"Irradiation of Superficial Cancer with Low Voltage Roentgen Rays"

Complete information concerning the above clinics will be published at a later date.

REFRESHER COURSES

The first annual "Refresher Series," postgraduate course, sponsored by the Radiological Society of North America, will be held at Pittsburgh, Penna., November 27 and 28, 1938. The following is a brief description of the Courses:

PHYSICS OF RADIATION

J. L. WEATHERWAX, M.A.
EDITH H. QUIMBY, M.A.

Characteristics of roentgen radiation. Dosimetry, isodose curves, depth dose charts. Classification technics. Definition of dosage. Recovery rates. Characteristics of radiation from radium or radon. Data concerning transmission by various filters, dosimetry, management of radiation. Biological effect of irradiation. Radiosensitivity, theories of radiation reaction, protective measures. Typical roentgen and radium therapy technics, factors to be considered. Records.

RADIOLOGY OF THE CHEST

WALTER W. WASSON, M.D.

(1) Anatomy of the lungs with corrosive specimens demonstrating the bronchi and their air cells and the arteries and veins. (2) Anatomy of the lungs and thorax as portrayed by the roentgen film. (3) A discussion of the physiology of the lungs and mechanics of the thorax, particularly as it pertains to roentgenology. (4) Diseases of the chest and particularly of the lungs with a discussion of their classification, portrayal, and diagnosis. (5) Radiation therapy of the thorax and especially a discussion of its hazards.

RADIOLOGY OF THE GASTRO-INTESTINAL TRACT

E. P. PENDERGRASS, M.D.

The course is planned to cover physiology of the gastro-intestinal tract, roentgenology of the gastro-intestinal tract, and physiology of the gall bladder in both formal and open forum discussion. Tentatively, the presentation will consist of a discussion of the physiology of the gastro-intestinal tract for one and one-half hours by Dr. Abbott, following which, one and one-half hours will be devoted to the roentgen examination of the esophagus, stomach, and small intestine by Dr. Pendergrass. Roentgenology of the colon will be covered by Dr. Gershon-Cohen at the fourth hour. Physiology of the gall bladder will be discussed by Dr. Ravdin during the fifth hour and the roentgenological aspect of the gall bladder by Dr. Pendergrass during the sixth hour.

Pathology of Tumors

W. Carpenter MacCarty, M.D.

(1) Brief historical sketch of the evolution of pathology, pathologists and radiologists, and the relation of each to the other and to clinical medicine. (2) Fundamentals underlying disease, the thing called inflammation and its relation to x-ray diagnosis and treatment. (3) Fundamentals of the evolution of neoplastic conditions, their physical and clinical characteristics, and their relation to x-ray diagnosis and radiological treatment.

(1) The language of disease. (2) Clinical and radiological classification of inflammatory and neoplastic disease. (3) Practical bio-pathological, physical, and radiological classification of disease. (4) Difficulties of examining boards and those examined. (5) Suggestions for review. (There will be a ten minute recess between each subject.)

Radiology of Bone Tumors

J. T. Murphy, M.D.

A course on radiology of bone tumors which is to be conducted as a clinical-pathological conference with Dr. Plinn F. Morse. The course is designed to emphasize differential diagnosis and treatment. The field of bone tumors is to be tersely classified and illustrated examples of each class presented.

Roentgen Analysis of Fractures

W. Edward Chamberlain, M.D.

Roentgen analysis of fractures will be presented systematically; apparatus will be employed to illustrate certain features. Fluoroscopic methods will be demonstrated and the many ingenious and helpful plans for the analysis and handling of fracture problems will be shown.

Radiology of Sinuses and Mastoids

George W. Grier, M.D.

Anatomy of sinuses and mastoids. Technical considerations in the production of radiographs of sinuses and mastoids; the author's plan of examination. Pathology of diseases affecting sinuses and mastoids. Roentgen interpretation; correlation of roentgen findings and pathologies. Radiation therapy of sinuses and mastoids.

The Executive Committee has ruled that no charge shall be made for enrollment. Rooms available require the limitation to sixty in each course. Enrollment return cards will be mailed to all members one month before the date of the Annual Meeting. Members of the Radiological Society will be given preference and enrolled in the order in which the cards are received. Only sixty will be enrolled in each course.

COMMUNICATION

MIDSUMMER RADIOLOGICAL CONFERENCE

The Fourth Midsummer Radiological Conference in the Rocky Mountains, sponsored by the Denver Radiological Club, was held Aug. 11, 12, and 13, 1938. The guest speakers were: Wendell G. Scott, A.B., M.D.; Lowell S. Goin, M.D., F.A.C.R.; Orville Meland, M.D., F.A.C.S.; B. R. Kirklin, M.D., F.A.C.R.; Ralph E. Herendeen, M.D.; R. R. Newell, M.D.; Daniel T. Quigley, M.D., F.A.C.R., and Ernst A. Pohle, M.D., Ph.D., F.A.C.R.

The following papers were read by their authors: "The Diagnosis of Thoracic Diseases Other than Tuberculosis," Wendell G. Scott, M.D., Saint Louis; "The Classification, Recognition, and Differentiation of Bone Tumors," Lowell S. Goin, M.D., F.A.C.R., Los Angeles; "Irradiation Therapy of Bone Tumors," Orville Meland, M.D., F.A.C.S., Los Angeles (discussion by Ralph E. Herendeen, M.D., New York City); "Clinical Indications for Roentgenologic Examination of the Gastro-intestinal Tract" (Samuel B. Childs Lecture), B. R. Kirklin, M.D., F.A.C.R., Rochester, Minn.; "Developments in the Practice of Radiology, with Special Reference to Roentgen Therapy" (Sanford Withers Lecture), Ralph E. Herendeen, M.D., New York City; "The Roentgenological Aspect of Collapse Therapy in Pulmonary Disease," Ernst A. Schmidt, M.D., Denver; "The Joint Changes in Hemophilia," Nathan B. Newcomer, M.D., Denver; "Fractures and Pseudofractures of the Sutures of the Skull," Frank B. Stephenson, M.D., Denver; "Pulmonary Infarction," Lowell S. Goin, M.D., Los Angeles; "The Radiological Diagnosis of Heart Disease, with Special Reference to Roentgen Kymography," Wendell G. Scott, M.D., Saint Louis; "Roentgenologic Studies of the Stomach and Duodenum Following Operation," B. R. Kirklin, M.D., F.A.C.R., Rochester, Minn.; "Arthritis," Kenneth D. A. Allen, M.D.,

Denver; "Errors in the Diagnosis of Spondylolisthesis," W. W. Wasson, M.D., Joseph Connell, M.D., and G. E. Sanford, M.D., Denver; "Quality of Roentgen Ray: Physical Aspects," R. R. Newell, M.D., San Francisco; "Etiological Factors in Some Forms of Cancer," Daniel T. Quigley, M.D., Omaha; "Radiation Therapy of Leukemia, Hodgkin's Granuloma, and Allied Diseases," Ernst A. Pohle, M.D., Madison, Wisc.; "Advances in Radiation Therapy," Paul R. Weeks, M.D., Denver; "Irradiation Therapy in the Treatment of Mixed-cell Tumor of the Parotid," Edward J. Meister, M.D., Denver; "The Treatment of Carcinoma of the Breast: Technic, Complications, and Results," Elizabeth Newcomer, M.D., Denver; "Quality of Roentgen Ray: Clinical Importance," R. R. Newell, M.D., San Francisco; "Roentgen Therapy in Carcinoma of the Uterus and a New Method of Dosage," Ralph E. Herendeen, M.D., New York City; "How can the Results of Irradiation in Carcinoma of the Rectum be Improved upon?" Orville N. Meland, M.D., F.A.C.S., Los Angeles.

Scientific exhibits were shown by the following: Ralph E. Herendeen, M.D., New York City, "The Effect of Irradiation on Bone Tumors"; Wendell G. Scott, M.D., St. Louis, "Kymographic Studies of Gastro-intestinal Movements"; Ernst A. Schmidt, M.D., Denver, "Collapse Therapy in Pulmonary Disease"; H. P. Brandenburg, M.D., Denver, "Metastatic Carcinoma of Lung"; Nathan B. Newcomer, M.D., Denver, "Hemophilic Joints"; Elizabeth Newcomer, M.D., Denver, "Metastases Following Carcinoma of the Breast"; F. B. Stephenson, M.D., K. D. A. Allen, M.D., and P. R. Weeks, M.D., Denver, "Practical Consideration of Bone Tumors"; "Skull Sutures and Pseudo-fractures"; W. Walter Wasson, M.D., Denver, "Spondylolisthesis"; C. E. Skomp, M.D., Denver, "Interesting Cases of Abdominal Pathology"; Cassie Belle Rose, M.D., Boulder, Colo., "Calcification of Neoplastic Disease of Bone Resulting from Irradiation"; "Lesions of the Colon, Chiefly of the Cecum"; Leonard G. Crosby, M.D., "Diaphragmatic Hernia."

BOOKS RECEIVED

Books received are acknowledged under this heading, and such notice may be regarded as an acknowledgment of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

ELEMENTARY SURVEY OF PHYSICS: A Non-mathematical Presentation with a Special Supplement for Pre-medical Students. By ARTHUR E. HAAS, PH.D., with the collaboration of IRA M. FREEMAN, PH.D. A volume of 203 pages. Published by E. P. Dutton & Company, Inc., New York City, 1938. Price: $1.90.

CLINICAL ROENTGENOLOGY OF THE DIGESTIVE TRACT. By MAURICE FELDMAN, M.D., Assistant Professor of Gastro-enterology, University of Maryland, Associate Roentgenologist, Sinai Hospital, Assistant in Gastro-enterology, Mercy Hospital, Baltimore, Maryland. A textbook and reference book dealing with the clinical, surgical, and pathologic aspects of all diseases of the digestive tract. A volume of 1,010 pages, 358 illustrations, 179 tables, with references to all 220 chapters. Published by William Wood & Company, Baltimore, 1938. Price: $10.00.

SURFACE AND RADIOLOGICAL ANATOMY: For Students and General Practitioners. By ARTHUR B. APPLETON, M.A., M.D. (Cantab.), Prof. of Anatomy in the University of London and Director of the Department of Anatomy in the Medical School of St. Thomas's Hospital, London, late Fellow of Downing College, Cambridge; WILLIAM J. HAMILTON, M.D., B.CH. (Belf.), D.Sc. (Glas.), F.R.S.E., Prof. of Anatomy in the University of London at the Medical College of St. Bartholomew's Hospital, London, late Deputy Director of the Dept. of Anatomy in the Medical School of St. Thomas's Hospital, London, and IVAN C. C. TCHAPEROFF, M.A., M.D., B.CH. (Cantab.), D.M.R.E., Asst. Radiologist of St. Thomas's Hospital, London. A volume of 311 pages, with 338 illustrations. Published by William Wood & Company, Baltimore, 1938. Price: $5.50.

OUTLINE OF ROENTGEN DIAGNOSIS: An Orientation in the Basic Principles of Diagnosis by the Roentgen Method. By LEO G. RIGLER, B.S., M.B., M.D., Professor of Radiology, University of Minnesota, Minneapolis. Atlas Edition; a volume of 226 pages; 254 illustrations shown in 227 figures, presented in drawings and reproductions of roentgenograms. (Figures 6 to 51 and 55 to 72 are drawings in an original technic by Jean E. Hirsch.) Published by J. B. Lippincott Company, Philadelphia, 1938. Price: $10.00.

ABSTRACTS OF CURRENT LITERATURE

CONTENTS BY SUBJECT

THE FOLLOWING ABSTRACTORS HAVE CONTRIBUTED TO THIS ISSUE

S. Richard Beatty, M.D., of Madison, Wis.
Irving I. Cowan, M.D., of Milwaukee, Wis.
J. Edwin Habbe, M.D., of Milwaukee, Wis.
Lewis G. Jacobs, M.D., of Winona, Minn.
E. T. Leddy, M.D., of Rochester, Minn.
J. B. McAneny, M.D., of Madison, Wis.
A. Mayoral, M.D., of New Orleans, La.
L. W. Paul, M.D., of Madison, Wis.
Ernst A. Pohle, M.D., Ph.D., of Madison, Wis.
Charles G. Sutherland, M.D., of Rochester, Minn.
J. E. Whiteleather, M.D., of Memphis, Tenn.

ABSTRACTS IN THIS ISSUE LISTED ALPHABETICALLY BY AUTHORS

HERNIA

A Case of Congenital Hernia of the Lung. Leroudier, J. L. Cousergue, and Popof. Jour. de radiol. et d'électrol., **22,** 23–25, January, 1938.

A case in which there was herniation of the lung into the tissues of the neck above the level of the cricoid cartilage is presented and discussed in detail.

S. R. BEATTY, M.D.

THE HIP JOINT

The First Stages of Coxa Plana. Henning Waldenström. Jour. Bone and Joint Surg., **20,** 559–566, July, 1938.

The author objects to the names "Perthes' disease," "Perthes-Legg disease," and "osteochondritis deformans" for this disease and insists on the term "coxa plana."

A study of cases of this disease in its earliest form was made, the group numbering 13. The x-ray appearance of the hip joints (always including both joints) in the conventional anteroposterior projection may not show definite abnormality, but by using Lauenstein's position (femur in flexion and abduction) early changes are seen in the femoral head.

Always comparing both joints, it is found that the femoral epiphysis on the diseased side is lower and flattened on its superior aspect. This is especially marked in Lauenstein's position. About the epiphysis superiorly a thin, faint line concentric with the epiphysis is found, which is the joint cartilage to which some bone still remains unabsorbed. There is also an increase in distance between the femoral epiphysis and the bottom of the acetabulum. This space is filled with synovia. Another point demonstrated is that the curved line of the posterior rim of the acetabulum, seen through the femoral head mesially, is less in coxa plana. In all the examined cases, the distance between the epiphysis and the bottom of the acetabulum has been increased.

J. B. MCANENY, M.D.

INFECTION

An Experimental Study of the Effect of X-radiation upon Acute Pyogenic Infection of the Skin and Subcutaneous Tissues. José A. Soto, Alexander Brunschwig, and F. W. Schlutz. Surgery, **3,** 593–600, April, 1938.

The authors used 105 rabbits as controls and experimental animals. X-rays were generated at 200 kv., 25 ma., and filtered through 1.0 mm. Cu plus 1.0 mm. Al at 50 cm. distance. *B. coli* and several strains of *Staphylococcus aureus* were used to produce infections. Croton oil, histamine di-hydrochloride, and trypan blue were used to study the effect of radiation upon lymphatic spread.

The authors conclude that moderate doses of the above radiation reduce the severity of the acute pyogenic infections in the skin but do not hasten the final healing of the lesions. In some instances the irradiated lesions healed more slowly.

There is some effect if the radiation is delivered before infection, but the optimal effect is obtained if irradiated shortly after. The effect decreases as the suppurative phase of the infection becomes more prominent.

Microscopic sections show no increase in lymphocytic destruction in the irradiated areas over the control areas.

There is a slightly greater absorption of soluble substances from inflamed areas after irradiation.

J. E. WHITELEATHER, M.D.

THE INTESTINES

Congenital Absence of Portion of the Small Intestine. John McGregor and Morris Rothenberg. Northwest Med., **37,** 134–136, May, 1938.

A case is reported of an apparently normal, new-born child who presented symptoms of intestinal obstruction a few hours after birth. The diagnosis was confirmed by x-ray study of the gastro-intestinal tract. Operative treatment was offered and an end-to-end anastomosis was done between two blind loops of intestine. The autopsy revealed absence of the small intestine from a point 30 inches below the ligament of Treitz, to about 29 inches proximal to the ileocecal valve.

In their comments the writers state that until 1922 only 401 such cases had been reported, and that since then only six additional cases have appeared in the literature.

A. MAYORAL, M.D.

Roentgen Diagnosis of Hepatodiaphragmatic Interposition of the Large Intestine. K. J. Kolji. Am. Jour. Roentgenol. and Rad. Ther., **39,** 928–936, June, 1938.

Out of 20,000 roentgenoscopies, the author observed 29 patients with hepatodiaphragmatic interposition of the large intestine. In all of the cases the finding was incidental.

The differential diagnosis roentgenologically includes an artificial or spontaneous pneumothorax and subdiaphragmatic abscess. Two types of interposition were found, a temporary and a permanent form. The first oblique position was found most suitable for showing some minor forms of interposition. Filling the intestine with contrast medium assisted in making the diagnosis in obscure cases.

IRVING I. COWAN, M.D.

Roentgenologic Studies of the Large Bowel in Infections by *Endamœba histolytica* Before, During, and After Treatment. Joseph C. Bell. Am. Jour. Roentgenol. and Rad. Ther., **39,** 916–924, June, 1938.

Three detailed case reports are given, with the roentgen findings. The deformity of the cecum characterized by an irregular narrowing resembling a cone, is the most constant and most characteristic change noted.

Under treatment, there is a decrease in the irregularity of the cecum and an increase in the diameter of the lumen. A relatively rare type of hyperplastic tuberculous infection might produce the same roentgen changes. The diagnosis in two of the author's cases was based almost entirely on the roentgen findings and the histories. The response to anti-amebic therapy proved the accuracy of the diagnosis in each case. One case of carcinoma of the colon with amebæ in the stool was presented to show how the differential diagnosis might be made on the basis of the appearance of the cecum and the response to anti-amebic therapy.

IRVING I. COWAN, M.D.

THE JOINTS

Anatomy of the Forked Clavicle and the Coracoclavicular Joint. C. Henschen. Schweiz. med. Wchnschr., **68,** 535–539, May 7, 1938.

Two anomalies are described. The first is a rare forking of the outer end of the clavicle. The abnormally forked bone may be one of two types; the supracoracoid (two cases reported), or the acromial. In the supracoracoid type, articulation of the fork and the coracoid process occurs. Simple articulation of the coracoid apophysis, and the inner, under aspect of the clavicle, is also described. Poirier states that it occurs in 30 per cent of cases. In this anomaly there is found a true joint of the diarthroidal type. Enlargement of the trapezoid ligament and cartilaginous infiltration of it occur. The etiology is discussed, and the rôle of fracture and epiphyseolysis of the coracoid considered. Some discussion of the phylogenetic significance of the anomalies is given. The author points out that this joint may be the seat of any joint disease, as illustrated by one of his case reports. Julliard's "coracoiditis" is probably a disease of this subclavicular joint.

L. G. JACOBS, M.D.

THE KNEE JOINT

Bursitis of Sartorius Bursa: An Undescribed Malady Simulating Chronic Arthritis. Eli Moschcowitz. Jour. Am. Med. Assn., **109,** 1362, Oct. 23, 1937.

This undescribed malady simulating chronic arthritis occurs for an unknown reason almost exclusively in women. These patients complain of pain in both knees only on descending or ascending stairs. Walking on the level is not painful. On examination, movement of the knee joint in both extension and flexion causes no pain. The joint itself is not tender. A tender area is found on the inner tibia at the exact site of the insertion of the sartorius, semitendinosus, and gracilis tendons. Occasionally a slight swelling is found in this area; as a rule only tenderness is present. X-ray examination of the joint reveals no evidence of arthritis.

The best results are obtained by treatment for reduction of weight.

CHARLES G. SUTHERLAND, M.D.

Pneumoroentgenography of the Knee Joint: An Analysis of 50 Cases. Paul A. Quaintance, Jour. Bone and Joint Surg., **20,** 353–362, April, 1938.

Between 100 and 150 c.c. of air is aseptically injected into the knee joint and x-ray films exposed in various positions. The internal structure of the joint and the soft tissues are better demonstrated than by the conventional x-ray studies. It is a harmless procedure and a great aid in accurate diagnosis of disease of the knee joint.

J. B. MCANENY, M.D.

THE LUNGS

Non-tuberculous Pulmonary Diseases with a Tuberculosis-like Roentgen Picture. R. Schoen and W. Naumann. München. med. Wchnschr., **85,** 287, Feb. 25, 1938.

First, diseases of miliary distribution are noted; miliary hematogenous, carcinomatous—lymphangiitis, carcinomatosa, bronchiolitis obliterans are mentioned as most frequent; muscular fibrosis (of Buhl) is rarer, but pneumoconiosis is common. This latter may be accompanied by tuberculosis.

Nodular indurative lesions are characteristic of fibrocaseous tuberculosis, but end-stages of pneumoconiosis, gummatous or interstitial pulmonary syphilis, chronic pneumonia, and bronchial carcinoma may lead to confusion. Occasionally chronic passive congestion (as in mitral valve lesions) may also be confusing, especially when it leads to hemoptysis.

Cavitation may take many forms. Isolated cavities with little infiltration or with broad borders may occur in lung abscess. Clinical findings will differentiate. Large irregular cavities occur in pulmonary gangrene. Cavity may occur in carcinoma of the bronchus beyond the stenosis. Multiple cavities occur in cystic lung and bronchiectasis.

Isolated infiltrations must be distinguished from nonspecific inflammations, tumors, and cysts, echinococcus or other.

Lobar involvement is not so common in tuberculosis, but may occur in caseous pneumonia. It is to be distinguished from unresolved lobar pneumonia and bronchial carcinoma with atelectasis.

Hilar infiltration offers much difficulty—tuberculosis, non-specific glandular enlargements, tumors, and thymus and thyroid enlargements are to be considered.

Since the diagnosis of such lesions is so complex, the use of clinical co-ordination with the roentgen findings is essential.

L. G. JACOBS, M.D.

A Case of Abscess in an Accessory Pulmonary Lobe. Raoul Molari. Minerva Med., **29,** 563, 564, May 26, 1938.

This is a case in which roentgen examination made the exact diagnosis of an abscess in a cardiac accessory lobe. The roentgenograms are reproduced.

E. T. LEDDY, M.D.

Solitary Air Cyst of the Lung. G. Ursace. Jour. de radiol. et d'électrol., **22**, 26, 27, January, 1938.

Because of its rarity, a case of solitary air cyst of the lung is reported.

S. R. BEATTY, M.D.

THE LYMPH GLANDS

Primary Tumors of Lymph Glands. T. Anardi. Riv. di Chir., May, 1937, **3**, 248–266. (Reprinted by permission from British Med. Jour., Sept. 11, 1937, page 38 of Epitome of Current Medical Literature.)

After describing the difficulties of classifying primary tumors of lymph glands other than in systemic diseases, Anardi divides them into three groups: (1) neoplasms of the parenchyma—lymphoblastoma, lymphocytoma, or lymphoma, according to the degree of cytological development; (2) neoplasms of the stroma—fibroma, lipoma, sarcoma, etc., and (3) neoplasms of the blood or lymph vessels—endothelioma and perithelioma, to which it appears that the reticuloma (histiocytoma) must now be added. Although the third group is undoubtedly malignant, it is not rare for the growth to be slow, the tumor to remain localized, and for surgical removal, followed by x-ray therapy, to effect a cure. Two such cases are reported, one a perithelioma and the other an inguino-crural and a suprahyoid lymph gland endothelioma, which latter was difficult to distinguish from paradental phlegmon. The lymphoglandular perithelioma is rarer than the endothelioma, and seems most common in or near Scarpa's triangle; it may rapidly produce metastases.

THE MASTOID

The Roentgenogram as an Aid in the Diagnosis of Surgical Mastoiditis: Comparison of Operative and Roentgen Findings in 100 Cases of Mastoiditis. Durwin H. Brownell and I. Jerome Hauser. Ann. Otol., Rhinol., and Laryngol., **47**, 240–246, March, 1938.

The authors reviewed the roentgenographic and surgical findings in 100 cases of surgical mastoiditis to determine the value of the roentgenogram in depicting the changes found at operation. The roentgenograms were viewed before the surgical reports in order that the conclusions might not be biased. Bone necrosis was recognized in about 80 per cent of the cases but an attempt to localize such destruction was found to be impossible. Efforts at roentgenographic recognition of disease of the sigmoid plate, semicircular canals, and petrosa were wholly unsatisfactory. Gross formation of cholesteatoma was recognized in four of 11 cases. The authors conclude that the clinical examination is of prime importance, that the roentgenogram is never entirely negative when a mastoid disease is found surgically, and that the roentgenogram probably never shows clouding when the mastoid is found normal at operation.

LESTER W. PAUL, M.D.

PEPTIC ULCER

Bleeding Peptic Ulcer in Meckel's Diverticulum. James E. Thompson. Jour. Am. Med. Assn., **109**, 938, Sept. 18, 1937.

A pre-operative diagnosis of a bleeding ulcer in a Meckel's diverticulum was made in this case. Grossly, the body of the diverticulum showed numerous prominent rugæ on its mucosal surface, which diminished in size as the neck was approached. Many pinpoint hemorrhagic areas could be detected in the mucosa. Microscopically the section showed a transition from intestinal mucosa to that of stomach mucosa, as it passed from the neck into the body of the diverticulum. The gastric mucosa showed the typical glandular formation, with the tubules lined by chief and parietal cells. The glands were numerous and the acid cells stood out prominently. No pancreatic tissue could be found. A definite peptic ulcer was found, which was in a healing phase. Beneath the ulcer base a large artery could be seen, with fibroblastic invasion filling two-thirds of its lumen; it was logically assumed that this represented the amount of healing and obliteration of the artery that had taken place since the child last gave evidence of hemorrhage.

The patient made an uneventful convalescence and has been symptom-free ever since.

CHARLES G. SUTHERLAND, M.D.

True Pyloric Ulcer. Ch. Garin and Pierre Bernay. Jour. de méd. de Lyon, **18**, 453–456, Aug. 20, 1937.

True pyloric ulcer, confined to the region of the sphincter, is relatively rare. Pain is the principal symptom but is frequently atypical. Stenosis is not particularly frequent. Gastrophotography shows the gross lesions of gastritis. Roentgenography effected under good conditions serves to identify pyloric ulcer but the diagnosis is nevertheless difficult in a certain number of cases. The roentgenologic diagnosis is discussed.

S. R. BEATTY, M.D.

Roentgen Therapy of *Ulcus callosum ventriculi* and *Ulcus pepticum jejuni post-operativum penetrans*. K. Breitländer. Strahlentherapie, 1938, **62**, 331.

The author has treated a few cases of gastric and jejunal ulcer with roentgen rays. Technic: 180 kv., 40 cm. F.S.D., 100 r per sitting, at 4.5 r/min., exposures every other day up to a total surface dose of from 1,000 to 1,500 r. The ulcer disappeared within from two to six weeks after the treatment. During the observation period of two years, 90 per cent remained free from symptoms, based on a total of 48 cases. The author believes that the protraction and fractionation of the dose are the decisive factors responsible for the good results. By no means should the dose be applied at a higher intensity than 5 r/min. Since his material is still small, he urges other radiologists to give his method a trial.

ERNST A. POHLE, M.D., Ph.D.

Partial Gastrectomy for Gastric or Duodenal Ulcer. Samuel F. Marshall and Everett D. Kiefer. Jour. Am. Med. Assn., **109**, 1341–1346, Oct. 23, 1937.

Certain clinical features have proved to be definite indications for surgical intervention in the management of patients with duodenal ulcer. It is obvious that acute perforation requires immediate surgical intervention. Patients with intractable ulcer, who for one reason or another fail to obtain relief with adequate medical care, are forced to submit to operation for control of their disease. Pyloric obstruction due to spasm, infection, or edema can be relieved by rest, diet, and alkalinization. However, recurring bouts of acute ulcer produce narrowing of the pylorus, shortening of the duodenum by scar formation, and real cicatricial stenosis, which necessitates surgery. Recurrence of gross hemorrhage in spite of adherence to a regimen for ulcer is a definite indication for surgical intervention. They have established the policy of advising surgical treatment for patients with serious recurrent hemorrhage.

A large percentage of gastric ulcers will heal readily and completely with medical treatment. Surgical treatment is therefore indicated only for the gastric ulcer which, because of the large size of the crater or extension into adjacent tissues, proves intractable with medical measures and for the ulcer which, because of insufficient tendency to heal during medical management, is suspected of being an early carcinoma. Recurrent massive hemorrhage is an indication for operation. Obstruction is rarely an indication for operation in cases of benign lesion.

The greatest benefit accomplished by the surgical management of ulcers results from the change in the gastric secretory and motor function, and there is little doubt that, of all operative procedures, partial gastrectomy best accomplishes this change.

The technical difficulties of such a formidable operation as partial gastrectomy, which involves removal of at least three-fourths or four-fifths of the stomach, are considerable and are to be surmounted only by an extensive experience with gastric surgery.

CHARLES G. SUTHERLAND, M.D.

PNEUMONIA

Lipoid Pneumonia and Oil in the Lungs. Editorial. Jour. Am. Med. Assn., **109**, 1367, 1368, Oct. 23, 1937.

Fatal cases of pneumonia due to aspiration of oily preparations into the lungs have been reported in the American medical literature as lipoid pneumonia since 1925. Liquid petrolatum is the chief etiologic agent. The condition is observed usually in children under 2 years, generally the result of too frequent installations of oily nose drops. The fats and oils which cause this disease reach the alveoli of the lungs, where they collect and give rise to chronic inflammatory processes resulting in fibrosis. Lipoid pneumonia of the adult type is a distinct clinicopathologic entity.

The typical pulmonary lesion represents a chronic, non-specific, non-suppurative, granulomatous foreign body leading to ultimate tumefaction and fibrosis. Patients show the clinical signs and symptoms of a low grade pneumonia. Roentgenograms usually show a shadow along the sternal border of the pulmonary fields. At necropsy the lungs show evidence of the reaction of the tissues to a foreign body and the results of secondary invasion by bacteria.

Oily nasal drops are not the only agents that may cause this form of pneumonia in infants; cod liver oil and even cream have been involved in some of the cases.

CHARLES G. SUTHERLAND, M.D.

THE PROSTATE

The Roentgen Diagnosis of the Prostate. L. Haas and K. Fillenz. Jour. de radiol. et d'électrol., **22**, 103–108, March, 1938.

The use of radiographic methods in the diagnosis of prostatic disease is not as general as the value of such methods would indicate. The authors prefer the injection of dye rather than air into the bladder. Not only the size of the prostatic enlargement, but also the deformity and secondary changes (such as diverticula) in the bladder, are defined. Several illustrative cases are presented.

S. R. BEATTY, M.D.

RADIATION BURNS AND INJURIES

Injuries to the Blood Vessels of the Heart and Their Prevention in the Protracted Fractional Treatment of Tumors of the Upper Air and Digestive Tracts. H. Bartsch and G. Wachner. Strahlentherapie, 1938, **62**, 339.

Patients undergoing x-ray therapy over the heart region sometimes develop circulatory disturbances. The authors recommend, therefore, prophylactic digitalization in combination with caffeine medication. This prophylactic treatment has proved very valuable in their experience.

ERNST A. POHLE, M.D., Ph.D.

A New Treatment of Persistent Ulcerating Radiodermatitis: The Application of Vitamin A. H. Sohier and L. Ginieys. Jour. de radiol. et d'électrol., **22**, 112–114, March, 1938.

The authors discuss the various therapeutic measures which have been used in the treatment of chronic ulcerative radiodermatitis. They present a case of extensive involvement of over six and a half years' duration, previously treated with a number of agents, which responded by rapid healing when treated with cod liver oil and other sources of vitamin A.

S. R. BEATTY, M.D

Ulceration of the Small Intestine Following Irradiation of the Pelvis: Report of Two Cases. I. A. B. Cathie. Am. Jour. Roentgenol. and Rad. Ther., **39,** 895–898, June, 1938.

In a series of nearly 400 cases treated for carcinoma of cervix uteri, two patients developed intractable diarrhea and died, although the roentgen dosage was well within the limits of normal tolerance. Since the lesions in the intestine were practically limited to the small intestine beyond the irradiated areas, the author believes that the changes produced were an example of severe irradiation sickness. He emphasizes the fact that all transient diarrheas should be regarded with the gravest concern.

IRVING I. COWAN, M.D.

Intestinal Injuries after Radium and Roentgen Treatment of Carcinoma of the Cervix. James A. Corscaden, Haig H. Kasabach, and Maurice Lenz. Am. Jour. Roentgenol. and Rad. Ther., **39,** 871–887, June, 1938.

The records of 350 cases of carcinoma of the cervix and 92 cases of carcinoma of the corpus, treated by radium, were carefully reviewed and there were 139 patients who had symptoms related to the lower alimentary system. In this group a large number developed a simple proctitis; severe inflammation was present in 16 cases; ulceration in 12 cases; cicatricial stenosis, one case; perforation, five cases; one case of obstruction by kinking of an uninjured intestine, and two cases of obstruction complicating persistent carcinoma. In all, 15 detailed case reports are given.

The anatomic findings showed that the injurious action of irradiation is selectively on the intestinal mucosa, with practically no effect on the muscular coats. The maximum injury in the majority of the cases is in the fixed portion of the lower colon, particularly at the distal end of the sigmoid. In the roentgenologic examination of the colon one must differentiate between a malignant growth of the colon, extension of the primary neoplasm from the cervix, and a post-irradiation colitis.

Radiation injuries were eliminated by reducing the number of milligrams used in the utero-vaginal application from 175 to 70 and increasing the duration of the application from 40 to 100 hours; by reducing the daily roentgen dose from 300–400 r to 100–200 r, and the size of the field from 20 × 20 cm. or 15 × 20 cm. to 10 × 15 cm. or less, and increasing the duration of the course of treatment from 21 to 30–40 or more days. Following this change in technic the incidences of intestinal injuries, which had been 8.7 per cent, dropped to *nil*.

IRVING I. COWAN, M.D.

Deteriorative Changes in Heredity Brought about by Irradiation. A. Pickhan. Strahlentherapie, 1938, **62,** 240.

The author analyzed the results of a number of investigations concerning the effect of radiation on mutations. He concludes that all rays of short wave length, beginning with ultra-violet down to the gamma rays of radium, may cause changes in the mutations and gene cells. The effect is in direct and linear proportion to the order of magnitude of the dose applied. The mutation rate is apparently independent of the wave length, and the time distribution of the dose. There is no recovery and the reaction is irreversible. From experiments on *Drosophila* eggs, he proposes a dose of 20 r as the total dose which can be applied safely to the gonads before and during their active period. Consequently, the administration of roentgen rays to human beings in the region of the generative organs both for diagnostic and therapeutic purposes must not exceed this safe dose as long as there is still a probability of pregnancy later. The fact that normal children have been born although the gonads of either parent had been exposed to higher doses of radiation does not prove the harmlessness of such exposures, because the major percentage of the mutations is recessive.

ERNST A. POHLE, M.D., Ph.D.

THE SKULL

A Roentgenological Study of Pineal Orientation. III.—A Comparison of Methods Used in Pineal Orientation. Walter W. Fray. Am. Jour. Roentgenol. and Rad. Ther., **39,** 899–907, June, 1938.

The author has devised two methods of pineal orientation, one of which, the proportional method, eliminates the need of consulting charts or making direct measurements with a rule. The method consists of using an elastic cord upon which are placed markers defining the normal zones for both the long and vertical diameters of the skull. The other method, the cranio-angle method, determines displacement along the vertical diameter of the skull.

The two methods described by the author are compared with the original Vastine and Kinney method and are found to reduce the error in normal cases approximately 50 per cent for measurements along the antero-posterior diameter and 33 per cent for measurements along the vertical diameter. In proven cases of brain tumor, pineal displacement was more frequently detected by the author than by the original graphic method of Vastine and Kinney. The analysis of the type of displacement does not yield positive information regarding sharp localization in the cerebral lobes, though an analysis of the data may permit the elimination of tumors in certain regions.

IRVING I. COWAN, M.D.

Value and Difficulties of Roentgen Diagnosis in Fractures of the Middle and Posterior Fossæ of the Base of the Skull. A. P. Lachapèle. Jour. de radiol. et d'électrol., **22,** 1–18, January, 1938.

Fractures of the middle and posterior fossæ are often missed, frequently because symptoms directing attention to these regions are absent, and the usual roentgenographic projections are insufficient to demonstrate these parts adequately.

A complete roentgenologic examination is necessary in all cranial traumatisms and will often reveal surprises.

Such an examination should follow strict rules of technic and completeness. It should include views in the four main planes (postero-anterior, lateral, vertical, and fronto-occipital) and special views of certain parts, as for instance, the temporal bone (Schüller's, Stenvers', and Mayer's projections).

Five illustrative cases are presented.

S. R. BEATTY, M.D.

THE SPINE

Roentgenologic Aspects of Spina Bifida Occulta. R. J. Dittrich. Am. Jour. Roentgenol. and Rad. Ther., **39**, 937–944, June, 1938.

The author's conclusions are based on a study of 33 cases of spina bifida occulta (lumbosacral region). The importance of these malformations in the spine lies in their association with abnormal tissue deposits within the sacral canal, so arranged that they may interfere with the normal function of the spinal nerves. These findings have been proven by operation. The abnormal tissue consists of fat tissue with varying amounts of fibrous tissue. Some of the clinical conditions which have been found to be combined with these abnormalities are muscular rheumatism, low back pain, spastic paralysis, infantile paralysis, and hematogenous osteomyelitis.

IRVING I. COWAN, M.D.

Diseases of the Apophyseal (Intervertebral) Articulations. Albert Oppenheimer. Jour. Bone and Joint Surg., **20**, 285–313, April, 1938.

This is an extensive study and discussion of diseases of the intervertebral apophyseal joints. The correct method of roentgenographing the joints is first discussed, then the types of disease affecting them are defined.

Atrophic Spondylarthritis.—The acute form occurs suddenly and shows a homogeneous hazy shadow extending slightly beyond the margins of the articular processes. It is usually limited to one joint. The disks and the vertebral bodies are normal. The chronic form is characterized by destruction of the cartilage, the joint space being narrowed.

Ankylopoietic Spondylarthritis is a typical atrophic arthritis involving all the apophyseal joints with demineralization of the vertebral column. It is characterized by narrowing of the joint space and demineralization of the articular process, which later become irregular. Subsequently the joint space becomes filled with new bone, resulting in ankylosis. Secondary changes may occur, consisting in ossification of the ligaments, corresponding to the clinical entity, *spondylose rhizomélique.*

Hypertrophic Spondylarthritis.—The primary lesion is in the cartilage, resulting in narrowing of the joint space, masked by articular effusion.

Primary hypertrophic spondylarthritis shows the processes increased in density, the facets ragged, the joint spaces irregularly narrowed, and exostosis on contiguous facets. Hypertrophic spondylarthritis may result from faulty posture.

Secondary infection, traumatic lesions, tumors and anomalies of the articular processes are discussed briefly.

J. B. MCANENY, M.D.

Pyogenic Osteomyelitis of the Spine, Mediastinal Abscess, and Compression of the Spinal Cord. Norman Q. Brill and David E. Silberman. Jour. Am. Med. Assn., **110**, 2001, 2002, June 11, 1938.

Only one similar case of this type is recorded in the literature.

The illness probably began with transient bacteremia, secondary to a furuncle on the face. Metastatic infectious involvement of the joints and the dorsal spine followed. There was extension from the spine into the mediastinum anteriorly, with abscess formation, resulting in diffuse pain in the chest, and later posterior extension into the epidural space, with consequent severe root pain. Slowly progressive compression of the cord then ensued, due possibly either to pressure of frank pus or to the formation of chronic epidural granulation tissue or both. It may have been due to changes in the cord secondary to involvement of the vessels. Operative intervention through the mediastinum permitted drainage and relieved the compression, as was revealed by the neurologic status six days after operation.

CHARLES G. SUTHERLAND, M.D.

Generalized Costo-vertebral Dystrophy. J.-P. Brinon-Cherbuliez. Bull. et mem. Soc. de Radiol. Méd. de France, October, 1937, **25**, 635, 636.

The author presents a case of a four-year-old infant with kyphosis and thoracic deformity due to multiple deformities of the ribs and spine, with irregular vertebræ, fused in several places, and with spina bifida occulta. He believes this to be an example of the syndrome of Klippel-Feil of atypical localization.

S. R. BEATTY, M.D.

Spondylolisthesis and its Evaluation in Determining Trauma. H. Zschau. München. med. Wchnschr., **85**, 599–603, April 22, 1938.

After a review of the present status of the question of spondylolisthesis, a critical comparison of the theories of the origin of spondylolysis was undertaken. From this comparison one reaches the viewpoint that the theory of congenital defect is well taken. It is further shown from two examples in which the question of judgment arose in relation to the connection with an accident. The roentgenogram can do good service here, if it is made promptly; that is, immediately after the accident. In each such case judgment requires a comprehensive consideration of the entire subject. Some good illustrations are appended.

L. G. JACOBS, M.D.

THE STOMACH

The Study of Inflammatory Gastric Granuloma. A. Rosselet, O. Mengis, and B. Ghelew. Schweiz. med. Wchnschr., **68,** 540, 541, May 7, 1938.

Report of a case of non-specific inflammatory granuloma of the stomach, in which roentgen signs of the mass were discovered. The correct diagnosis was made only at autopsy, a laparotomy also failing to show the true nature of the process. Although more than one hundred cases of this condition are in the literature, none has ever been clinically diagnosed. The authors conclude that differential diagnosis by use of roentgen examination is likewise impossible.

L. G. JACOBS, M.D.

Information Furnished by Radiologic Study of the Stomach in Dorsal Decubitus. P. Dufour. Bull. et mém. Soc. de Radiol. Méd. de France, **26,** 116–118, February, 1938.

The author stresses the importance, in examination of the stomach with the opaque meal, of utilizing a number of positions from upright to Trendelenburg, varying the incidence of the rays in each position. The patient is examined in multiple positions with a small amount of barium and the procedure repeated with the full meal. Radiographs are taken in all positions to register details not observable by radioscopy. The advantages of such a complete examination are discussed.

S. R. BEATTY, M.D.

SUPERVOLTAGE

Biophysical Foundations of Supervoltage Roentgen Therapy. Otto Glasser. Cleveland Clinic Quarterly, **5,** 196–202, July, 1938.

The different methods of supervoltage (*i.e.*, above 200 kv.) production are discussed. The location of some of these installations is mentioned.

The biophysical advantages of supervoltage are given as: (1) Greater output of radiation, permitting heavier filter and greater focal-skin distance with greater depth dose; (2) greater penetration resulting in higher half value layers; (3) the possibility that the short and penetrating rays have selective action; (4) production of new types of rays, *e.g.*, neutrons, high-speed cathode rays, and artificial radio-active substances.

J. B. MCANENY, M.D.

SYPHILIS

Two Cases of Syphilitic Osteitis Resembling Osteogenic Sarcoma. Nils Westermark and Sven Hellerström. Acta Radiol., **18,** 422–427, May, 1937.

The summary is as follows: "The authors report two cases of syphilitic osteitis which closely resembled osteogenic sarcoma both clinically and roentgenologically. The latter diagnosis should not be made on the basis of the roentgen film alone. A syphilitic etiology should be excluded by careful clinical study, by the Wassermann and Müller-Ballung reactions, and by a trial of anti-syphilitic treatment in all such cases in which osteogenic sarcoma is suspected, before taking the responsibility for the mutilating treatment which this latter disease requires."

AUTHORS.

A Diagnostic Difficulty: Syphilitic Meningo-myelitis or Spinal Arachnoiditis (?). H. Tillier, F.-G. Marill, R. Raynaud, and J.-R. D'Eshougues. Bull. et mém. Soc. de Radiol. Méd. de France, **25,** 750–753, November, 1937.

A case presenting radiologic evidence of arachnoid adhesions, which had clinical evidences of a myelitis, offered considerable difficulty in diagnosis, as the blood and spinal fluid gave negative reactions for syphilis. The clinical improvement after anti-syphilitic therapy made possible the diagnosis of syphilitic meningomyelitis with arachnoiditis.

S. R. BEATTY, M.D.

THE THYMUS

The Incidence of Enlarged Thymus Following the Prenatal Use of Iodized Salt. S. W. Donaldson and J. A. Towsley. Am. Jour. Roentgenol. and Rad. Ther., **39,** 908–915, June, 1938.

The literature is reviewed to show the relationship of thyroid disease and thymic hyperplasia. A series of roentgenograms of the thymus was taken before the introduction of iodized salt and this group is compared with a recent series after the introduction of iodized salt. The comparison indicates a decrease of approximately 55 per cent in the incidence of thymic enlargement.

IRVING I. COWAN, M.D.

TUBERCULOSIS, PULMONARY

Stenosis of the Pulmonary Artery and Pulmonary Tuberculosis. F.-G. Marill and R. Raynaud. Bull. et mém. Soc. de Radiol. Méd. de France, **25,** 745–747. November, 1937.

In a case of stenosis of the pulmonary artery the onset and course of fatal pulmonary tuberculosis was rapid. The focus was probably a large calcified area in the hilum, and the rapidity of progression probably associated it with pulmonary congestion.

S. R. BEATTY, M.D.

Hematogenous Pulmonary Tuberculosis. William A. Zavod. Jour. Am. Med. Assn., **109,** 1693–1698, Nov. 20, 1937.

Pulmonary hematogenous tuberculosis is a pulmonary dissemination of the bacilli of tuberculosis by way of the lesser blood circle, mainly, in contradistinction to generalized miliary tuberculosis, which is a widespread

dissemination of the bacillus of tuberculosis by way of both the greater and the lesser blood circles.

A roentgenogram of the lungs invaded by such a dissemination will show miliary seeding throughout both lungs and the roentgenologist will justly report "miliary tuberculosis." The clinical picture, however, while that of miliary tuberculosis in some cases will show very little to justify such a diagnosis in others. The fatal type of miliary tuberculosis and the comparatively benign dissemination "hematogenous tuberculosis" appear nearly alike roentgenographically; one must turn to the clinical signs and symptoms and possibly to a period of observation as the basis for a differential diagnosis.

Pulmonary hematogenous tuberculosis occurs most frequently during childhood and in young adults who were heavily exposed to tuberculosis during childhood. Repeated attacks are not infrequent. Continued close contact with open cases of tuberculosis favors repeated disseminations, especially in childhood. Undernourishment and general poor health are additional predisposing factors.

Early hematogenous disseminations show an evenly distributed seeding of nodules varying in size from one to several millimeters, with the greatest density in the upper halves in the roentgenogram. The hilar nodes may either be still large or show heavy calcium deposition. Periodic roentgenograms of retrogressive lesions show a gradual caudo-apical fading out of the infiltrations, and the nodules in the upper portion of the lung persist the longest. In some cases all roentgenographic evidence of disease may disappear within a few months to a year. In other cases the fine hematogenic nodules may become fibrosed or even calcified and persist throughout life. Dense invasion of the upper halves of the lungs may lead to heavy fibrosis, appearing as dense homogeneous shadows symmetrically distributed; the lower halves show increased transillumination due to emphysema.

CHARLES G. SUTHERLAND, M.D.

Pulmonary Tuberculosis and Syphilitic Aortitis Associated. Ch. Viallet, R. Marchioni, and A. Lévi-Valensi. Bull. et mém. Soc. de Radiol. Méd. de France, **25**, 742–745, November, 1937.

Fibro-ulcerative tuberculosis is more frequent in syphilitics than in the general run of cases. A case of syphilitic aortitis and pulmonary tuberculosis characterized by cavitation, marked fibrosis, and calcification is presented.

S. R. BEATTY, M.D.

Co-existing Pulmonary Tuberculosis and Primary Carcinoma of Lung. Charles P. Larson. Northwest Med., **37**, 183, 184, June, 1938.

Reviewing the current literature the essayist finds "a great divergence of opinion as to the frequency of co-existing active pulmonary tuberculosis and primary carcinoma of the lung." Series of autopsies compiled by different men, some showing high incidence, others low incidence, are cited. The statistics from the larger tuberculosis clinics, however, show the co-existence of primary carcinoma of the lung and pulmonary tuberculosis to be extremely rare.

F. G. Cooper reviewed the literature in 1934 and was able to collect only 39 cases of this type. E. J. Simons is quoted as saying, "Statistics prove that tuberculosis is not an important cause of carcinoma but it may be considered responsible for the origin of carcinomas in a small proportion of cases, more on the grounds of chronic irritation and metaplasia than on any other."

The writer believes that the frequency of the co-existence of these two conditions has not been established and that it is rather difficult to understand how a cancer could originate in the wall of a tuberculous cavity lined by connective tissue. However, he further states that a bronchus may connect with this cavity, from which the cancer may possibly originate.

Two cases in which tuberculosis and primary malignancy of the lung co-exist are reported, and in his comments Larson states, "Both of these cases would tend to substantiate Ewing's viewpoint that tuberculosis is one of the etiologic factors in the production of primary carcinoma of the lung."

A. MAYORAL, M.D.

Tomography in the Radiology of the Chest. F. G. Stewart. Irish Jour. Med. Sci., sixth ser., No. 150, June, 1938, pp. 277–282.

This is a study of 50 cases of pulmonary tuberculosis by the usual x-ray method and by tomography. The latter study enhances the findings in chest conditions. The usefulness of chest tomography is classified as follows:

I. Demonstration of unsuspected findings radically altering the conception of the disease.

II. Demonstration of unsuspected findings modifying the conception of the disease.

III. Demonstration of unsuspected findings not appreciably modifying the conception of the disease.

IV. More precise demonstration of suspected findings.

V. Confirmation of plain films. Nothing new added.

Cases are presented demonstrating each class. The admonition not to exclude other methods of examination is given. The greatest advantage of chest tomography seems to be in those cases showing pathological lesions in the plain films.

J. B. MCANENY, M.D.

TUBERCULOSIS, SURGICAL

Operative and Conservative Treatment of Tuberculosis of the Spine: A Comparative Study. Harry Finkelstein, Benjamin B. Greenberg, Samuel A. Jahss, and Leo Mayer. Jour. Am. Med. Assn., **110**, 480–483, Feb. 12, 1938.

This was a comparative study extending over a ten-year period and limited strictly to children up to the

age of 20 years. Tuberculosis in the adult differs radically from the disease in children. Patients admitted to the country home of the Hospital for Joint Diseases were divided as impartially as possible into two groups, each of which was given exactly the same dietetic and general hygienic treatment, but in one group fusion operations were done and in the other conservative methods alone were followed. In all, 43 cases were studied: 26 patients were treated by fusion procedures and 17 by purely conservative measures. The authors' criteria for cure were: (1) Pain, fever, muscle spasm, and tilt of the body must completely disappear for at least three months; (2) abscesses must disappear both clinically and roentgenographically and sinuses must close; (3) in the roentgenogram there must be evidence of increased calcification in the area of destruction, cessation of all advance of the process, and a so-called bloc formation.

The fusion operation did not shorten the duration of the disease but, on the contrary, prolonged its course. The pathologic process in the vertebræ was apparently uninfluenced by the operation. The progression seemed to occur despite fusion.

CHARLES G. SUTHERLAND, M.D.

Spontaneous Fracture in Isolated Tuberculosis of the Shaft of the Ulna. C. H. Grasser. Schweiz. med. Wchnschr., **68,** 533–535, May 7, 1938.

A case of a proven isolated tuberculosis of the upper end of the ulnar shaft with pathologic fracture is reported because of its rarity. The fracture united with some improvement in the status of the tuberculosis. No other tuberculous foci were found.

L. G. JACOBS, M.D.

Tuberculosis of a Supernumerary Vertebra. Lauro Laureati. Minerva Med., **29,** 396, April 7, 1938.

The author claims that his is the first case to be reported. The lesion occurred in a supernumerary vertebra in a baby of 14 months.

E. T. LEDDY, M.D.

TUMORS, DIAGNOSIS

Ovarian Fibroma with Ascites and Hydrothorax (Meigs's Syndrome): Report of Case. J. E. Rhoads and Alexander W. Terrell. Jour. Am. Med. Assn., **109,** 1684–1687, Nov. 20, 1937.

The syndrome of fluid in the chest associated with ovarian fibroma was recently reported. The knowledge that this association of pleural effusion with a benign pelvic tumor exists is extremely important from the standpoint both of prognosis and of treatment, since most pelvic tumors causing pleural effusion are malignant and the effusion is the result of pleural or pulmonary metastasis. In the presence of massive pleural effusion it may at times be impossible, even after partial aspiration, to exclude the presence of pulmonary metastasis by x-ray examination.

The occurrence of hydrothorax with a pelvic tumor justifies abdominal exploration and promises substantial hope of recovery in a considerable group in which the prognosis was previously regarded as hopeless.

The mechanism of the relationship is not known. Several explanations of the ascites associated with ovarian fibromas seem plausible, but no explanation of the hydrothorax has as yet been afforded.

CHARLES G. SUTHERLAND, M.D.

Stenosis of the Duodenum by a Tumor of the Third Portion. Albert Poirier. Bull. et mém. Soc. de Radiol. Méd. de France, **25,** 771–773, November, 1937.

A case of lymphocytoma (sarcoma?) of the third portion of the duodenum, causing almost complete obstruction, is presented by the author.

S. R. BEATTY, M.D.

A New Case of Osteosarcoma of the Ischium Treated as Sciatica and Revealed by Radiography. T. Nogier. Bull. et mém. Soc. de Radiol. Méd. de France, **26,** 112, 113, February, 1938.

A patient shown to have extensive destruction of the ischium and part of the ilium and pubis had been treated for over 18 months for sciatica by a number of doctors who failed to take roentgenograms.

S. R. BEATTY, M.D.

A Case of Myeloma. L. Magnabosco and M. Francescon. Minerva Med., **29,** 387–390, April 7, 1938.

The authors report a case of myeloma which involved a rib and a vertebra in a man 34 years of age. The diagnosis was confirmed by x-ray examination and by sternal puncture. The lesion was of the monocytic type.

E. T. LEDDY, M.D.

Considerations on the Multiple Manifestations, Osseous and Glandular, of a Malignant Lymphoid Tumor. L. Berard, P. Ponthus, and A. Notter. Bull. et mém. Soc. de Radiol. Méd. de France, **26,** 104–106, February, 1938.

The authors discuss the difficulty of arriving at a final diagnosis, despite histologic and radiologic studies, of a case of neoplasm of the left ilium with metastasis to the regional nodes, mediastinum, and pleura. The tumor was probably a lymphoblastoma.

S. R. BEATTY, M.D.

The Relation of the Presenting Symptoms to the Selection of the Method of Treatment in Uterine Myoma. Henry Schmitz. Am. Jour. Roentgenol. and Rad. Ther., **39,** 849–854, June, 1938.

The methods of treatment of uterine myomas that produce symptoms are medical, surgical, and radiological. From a study of 263 consecutive cases of uterine

myomas, the author has found that there are indications for each type of treatment based on (1) the symptoms (menorrhagia, metrorrhagia, pain, or a combination of these symptoms), (2) the relation of these symptoms to the physical findings, and (3) the age groups.

The indications for the various forms of treatment are described and the author shows by a review of his cases that the results of the selection of the method of treat ment had been a very low mortality and morbidity, and a high percentage of cure.

IRVING I. COWAN, M.D.

Primary Malignant Tumors of the Urogenital Tract in Infants and Children. Meredith F. Campbell. Jour. Am. Med. Assn., **109**, 1606–1611, Nov. 13, 1937.

Hypernephroma accounts for from 2 to 11 per cent of malignant renal tumors in children and appears to be more common in girls. Hypernephroid tumors by biologic assay have shown a content of cortical hormone (adrenal cortex extract) comparable in amount to that found in the normal adrenal. This tends to support the Grawitz theory of adrenal cell rests as the origin of these tumors. Hypernephroma metastasizes by the lymphatics, blood stream, and direct extension; the lungs and long bones are most apt to be involved. Hematuria is the dominant early symptom of hypernephroma in children, quite in contrast to the initial symptom of a mass in the loin such as occurs in Wilms' tumor. Sometimes the passage of large blood clots produces renal colic, but otherwise pain in the loin is due chiefly to distention of the renal capsule by the growth. When the diagnosis is made early and prompt nephrectomy follows, the prognosis is slightly better than for Wilms' tumor. The results of irradiation are not as phenomenal in patients with hypernephroma as in those with Wilms' tumor, yet such therapy may advisedly be employed both pre-operatively and post-operatively. Chief reliance must be placed on early diagnosis and nephrectomy.

Embryonal adenomyosarcoma (congenital mixed tumor, Wilms' tumor) is the commonest neoplasm of the urinary tract and abdomen in the young, in whom it constitutes about a fifth of all tumors. Seventy-five per cent of Wilms' tumors appear before the fifth year, and two-thirds appear before the third year, which is about the average age at which the tumors are first recognized. After the seventh year hypernephroma is more apt to occur than embryonal adenomyosarcoma.

In Wilms' tumor a fifth of the patients show metastasis. The spread is characteristically through the blood stream, yet by lymphatic or direct extension the liver, spleen, spine, intestine, diaphragm, and lungs may be invaded. Less frequently the skull, brain, scapula, ilium, abdominal and lumbar muscles, and even the corpora cavernosa have been the site of metastasis.

Intravenous (excretory) urographic studies may suffice to make the diagnosis. Only a retrograde pyelogram can be relied on for a clear urographic demonstration of the pelvis of a tumor-bearing kidney in a child.

Tumors of the renal fibrous capsule are extremely rare; when found they are predominantly sarcomatous. Tumors of the renal pelvis are so scarce in children as to merit scant clinical consideration.

Tumors of the ureter in children are almost exclusively secondary to renal tumors and, even so, are seldom seen.

Tumors of the bladder are most unusual in children and are predominantly of mesodermal origin; more than half are sarcomas, a few are myxomas, and the remainder are fibroids, polyps, rhabdomas, dermoids, myomas or papillomas.

Malignant growths of the penis and urethra are almost unknown in the young.

Approximately 150 cases of tumor of the testicle in children have been reported. Examination of the growths shows them to be of congenital or embryonal origin. The embryonal tumor is the one characteristically seen in children.

Tumors of the prostate are extremely rare and in children are almost exclusively sarcomatous.

The important malignant adrenal tumor in children is the neuroblastoma or neurocytome; it occurs fully a third as often as malignant renal tumors. Neuroblastomas grow rapidly and not only push the kidney down but are likely to protrude posteriorly—a point differentiating them from renal tumors. The growths metastasize rapidly, principally through the lymphatics.

CHARLES G. SUTHERLAND, M.D.

A Case of So-called "Kahler-Bozzolo Syndrome." Angelo Sacchetti. Minerva Med., **29**, 360–363, March 31, 1938.

This syndrome, also called "multiple myeloma," is characterized by painful, brittle bones, anemia, asthenia, and the elimination of Bence-Jones protein in the urine. Roentgenologically there are numerous irregularly sized and shaped areas of absorption in the bones involved. In the author's case the possibility of metastatic carcinomatous involvement of bone seems to have been eliminated and it is, therefore, a true case of multiple myelomas. There was no autopsy.

E. T. LEDDY, M.D.

Radiologic Study of a Rounded Interthoracic Shadow. L. Berard, P. Ponthus, and A. Notter. Bull. et mém. Soc. de Radiol. Méd. de France, **26**, 102–104, February, 1938.

The differential diagnosis of an interthoracic tumor in a man with an epithelioma of the nose and von Recklinghausen's disease is discussed, with reference to metastatic malignancy, neuroma, von Recklinghausen's tumor, and dermoid cyst.

S. R. BEATTY, M.D.

The Roentgen Aspect of Sympathetic Neuroblastoma. Howard P. Doub. Jour. Am. Med. Assn., **109**, 1188–1191, Oct. 9, 1937.

Sympathetic neuroblastomas (neuroblastomas or sympathoblastomas) are neurogenic in origin. The

tumors arise from undifferentiated cells of the sympathetic nervous system, though their origin is not confined to adrenal tissue. They may also arise in the sympathetic ganglions along the spine, especially in the cervical area. These tumors are seen most commonly in children under the age of 4 years but may also occur in adults and are said to be more common in males. They are in all probability congenital.

An abdominal mass may be the first most prominent observation. In some cases the metastatic lesions attract the first attention. The clinical course is usually characterized by a rapid decline, followed by death in a few months. There may be manifestations of temporary improvement following radiotherapy, but relapse soon occurs. The local tumors frequently appear to respond to radiotherapy, but this has no apparent effect on the development of distant metastasis.

The roentgenographic changes in the skull consist of widening of the sutures and increased digital markings indicative of increased intracranial pressure. In addition, there is evidence of involvement of the bones of the skull, manifested by minute foci of resorption, which produces a finely granular type of osteoporosis. The flat bones of the pelvis show a type of infiltration similar to that in the skull.

This type of involvement appears to be the characteristic lesion in the flat bones. In the long bones, various types of lesion are seen. Elevation of the periosteum is frequently present and may be local or may extend along the entire length of the shaft. Areas of metastatic involvement, with bone resorption, are seen in any of the long bones. These changes are more apt to be in the ends of the diaphyses, adjacent to the epiphyseal lines. In advanced cases these changes may extend the full length of the shaft of the bone. In many instances the resorption is of uneven density, suggesting a diffuse infiltration rather than a massive destruction. Osteoporosis of an extreme grade may precede actual dissolution of the bone structure.

CHARLES G. SUTHERLAND, M.D.

Tumorlike Picture in Tabetic Arthropathy. W. Schröder. München. med. Wchnschr., **85,** 911–914, June 17, 1938.

The author points out that a Charcot joint of the hip is easily confused clinically with tumor. The swelling, usually painless, irregular, bony hard, and slow-growing, resembles chondroma or sarcoma. The roentgenologic distinction is not so difficult. In chondroma, the cystic rarefactions are surrounded by compacta and often by periosteal layers. Sarcomas may be either osteolytic or osteoplastic, usually localized below the metaphysis, and are not sharply demarcated. Epiphyseal and joint cartilage is seldom crossed. In tabes, marginal proliferation, loss of joint space, dislocations, and fractures in various stages of healing with exuberant callus, irregular bone ends, periosteal deposits, and capsular calcifications and ossifications are seen. Four case reports in which diagnostic difficulties arose are cited.

L. G. JACOBS, M.D.

TUMORS, THERAPY

Statistical Results of Treatment of Cutaneous Fibromas and Epitheliomas by Radiotherapy of Moderate Penetration. Ducellier. Bull. et mém. Soc. de Radiol. Méd. de France, **25,** 778, November, 1937.

Fibromas: Method of Béclère.—Fibromas treated, 153; cured in 16 sittings, 142 (92.8 per cent); cured in more than 16 sittings, 3; total cures, 145 (94.7 per cent); not cured, 8 (5.3 per cent). The cases not cured were eight errors in diagnosis: co-existence of fibroma with cancer of the body, of fibroma and ovarian cyst.

Cutaneous epithelioma

	Cases treated	Cured by first treatment	Cured after recurrence	Total cures	Not cured
Epithelioma of face	353	304 (86.1%)	17	321 (90.9%)	32 (9%)
Epithelioma of lips	43	30 (69%)	3	33 (76%)	10 (24.2%)
Epithelioma of eyelids	30	27 (90%)	2	29 (96.6%)	1
Epithelioma of back of hand	7	5 (71.3%)	0	5 (71.3%)	2
Total	433	366 (84.5%)	22	388 (89.6%)	45 (10.3%)

S. R. BEATTY, M.D.

A Case of Chorioepithelioma Cured by Irradiation Therapy. G. Melot. Bruxelles-méd., **17,** 1407–1412, July 25, 1937.

This case of chorioepithelioma of the anterior portion of the vagina in a woman of 39 years was treated with radium and x-rays in December, 1935. In March, 1937, she was alive and in good health and the Friedman-Brouha test was negative. The dose given with the radium was equivalent to 9,000 r at 12 mm. and external irradiation through four fields was given to a depth dose of 1,800 r. The author has reviewed the literature and discusses the diagnosis and treatment of chorioepithelioma in some detail.

S. R. BEATTY, M.D.

The Effect of Short Electric Waves on Malignant Tumors. S. Baumeyer. Strahlentherapie, 1938, **62,** 373.

The author briefly discusses the literature regarding the effect of short electric waves on malignant neoplasms. He had an opportunity to study the combined effect of short electric waves and x-rays on metastatic nodules in the thigh of a woman who had a primary carcinoma of the cervix. One nodule was treated by the combined method, the other nodule by

x-rays only. A comparison of the two nodules 10 days after the last treatment showed that the nodule which had received x-rays alone was smaller. The author deduces, therefore, that short electric waves have no influence on malignant tumors, that simultaneous treatment of malignant tumors by short electric waves and roentgen rays may cause an increase in the size of the growth, that a sensitization is apparently not possible, and that, therefore, malignant tumors should not be subjected to treatment by short electric waves.

ERNST A. POHLE, M.D., Ph.D.

Treatment of Cancerous Adenopathies Secondary to Malignant Tumors of the Upper Air and Alimentary Passages. L. Ducuing. Bull. et mém. Soc. de Radiol. Méd. de France, **25,** 764–768, November, 1937.

The author discusses briefly the anatomy, pathology, and clinical considerations in treatment of metastatic carcinoma from foci in the upper air and alimentary passages. The treatment, considered more in detail, is either surgical, radiologic, or combined. While surgery occupies a very definite place, it is becoming more and more replaced by radiologic methods, telecurietherapy or roentgen irradiation by the method of Coutard.

S. R. BEATTY, M.D.

Urography in Infants. Einar Perman and A. Lichtenstein. Acta Radiol., **18,** 413–421, May, 1937.

The summary is as follows: "The authors describe a method of obtaining urograms on infants by means of subcutaneous and intramuscular injection of 7.5 per cent perabrodil solution. A prerequisite for a very good result is that the child sleep during the procedure for only then is a compression of the ureters effective. Luminal or chloral are, therefore, given before the investigation. Good urograms have been obtained on children as young as three months of age."

AUTHORS.

THE UTERUS

X-ray Treatment of Carcinoma of the Cervix. Carlo Guarini. Archivio di Radiologia, **13,** No. 4, 348, 349, 1937.

This is a statistical analysis of 569 cases of carcinoma of the cervix treated between 1922 and 1936. In general, the best results were obtained by a modified Wintz technic in that treatment was not given in one session. Of the 569 cases, 31.8 per cent were living at the end of 1936. The highest mortality was in Groups III and IV. The final result in 19 per cent of the cases is unknown. Within from one to five years after treatment, 34.1 per cent died. He obtained the best results in cases in Group I, only 3 per cent of the total number, of which 36 per cent are living up to ten years after treatment.

E. T. LEDDY, M.D.

Radium *versus* Roentgen Radiation in the Treatment of Benign Uterine Bleeding. John W. Cathcart. Am. Jour. Roentgenol. and Rad. Ther., **37,** 513, April, 1937.

The writer has come to the conclusion in recent years that patients treated by roentgen rays for benign uterine bleeding do better than those who receive radium alone or radium plus x-rays. This impression is based upon the general feeling of well-being of the patient while under observation and treatment, the extent of psychic trauma incident to the procedure, the number and severity of post-treatment complaints, and the smoothness of the patient's life in medical matters in subsequent years.

The opinion of other radiologists representative of American radiation therapists was sought and it was found that the majority favored roentgen radiation except under circumstances and in patients in whom it was obviously desirable to use radium. If the more slowly induced menopause is less disadvantageous to the patient from the general standpoint, then the roentgen ray should be given preference.

J. E. HABBE, M.D.